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Protecting Orchard Crops from Diseases and Insects

C. R. Crosby, W. D. Mills, and W. E. Blauvelt

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PROTECTING ORCHARD CROPS FROM DISEASES AND INSECTS

C. R. Crosby, W. D. Mills, and W. E. Blauvelt

In this bulletin an attempt is made to bring together in available form all the more important facts concerning the practical control of orchard diseases and insects by spraying and dusting under New York conditions. Much of the material has been published in bulletins or elsewhere but is available only to those having access to an extensive agricultural library. Considerable additional information has been obtained from unpublished data of the research workers of the state experiment stations. Many valuable suggestions have been received also from the farm-bureau workers engaged in conducting the spray information service. Furthermore, the practices followed by successful fruit-growers have been given careful consideration, for the final test of any spraying program must be the results obtained under commercial conditions. It is hoped that this summary will be of use to the growers of the State in their efforts to produce clean crops of fruit economically.

The staff of the New York State Agricultural Experiment Station at Geneva has cordially cooperated in the present revision of this bulletin. The results of all experiments conducted by that station during 1933 have been made freely available and have been used as a basis for numerous changes in the recommendations given.

APPLE

In working out an effective spray program for apples, the most important problems to be solved are the control of apple scab, of codling moth, and of rosy aphis. While these troubles vary in relative importance with the year and the locality, they are always of sufficient importance in New York to be given careful consideration in planning a spray program. Occasionally, sooty blotch, the bud moth, the leaf-roller, and the green aphis become of major importance either locally or generally throughout the State. Other diseases and insects are restricted in importance to more or less definite areas. Owing to these variations in importance of the different insects and diseases with locality and year, the following schedule must be considered as a general outline of the spray program, to be modified to meet the actual conditions in the orchards to be treated. In counties where the farm bureau conducts a spray information service, valuable assistance in adapting the general recommendations to individual needs may be obtained on request.

SPRAY OUTLINE FOR APPLES

Dormant

For the control of rosy aphis, tar-distillate emulsion containing 2.4 per cent of creosote oil in the diluted mixture may be applied while the buds are dormant. If it is desired also to control oyster-shell scale, light infestations of scurfy scale, and bud moth, a 3-per-cent mixture should be used. If the infestations of scurfy scale or bud moth are heavy, a 4.5-per-cent mixture is indicated. Commercial tar-distillate emulsions vary greatly in

composition. Proper dilutions are given in table 2 on page 83. Tar-distillate emulsions should not be applied after the buds have begun to show gray at the tip or on trees that are winter-injured.

For San José scale and red-mite eggs, a 3-per-cent lubricating-oil emulsion may be used. Under certain conditions the oil emulsion may be combined with a tar-distillate emulsion. (See tables 3 and 4, page 83.)

For the fruit-tree leaf-roller, lubricating-oil emulsion diluted to contain 6 per cent of oil in the spray should be applied. This treatment is advised only when 10 per cent or more of the picked crop has shown leaf-roller injury or when no apples have survived the attack of the insect. The treatment is best made after the buds have begun to swell but before they show green at the tip.

Delayed dormant (When the leaves of the blossom buds are out from ¼ to ½ inch)

Lime-sulfur	2½ gallons
Lead arsenate	3 pounds
Nicotine sulfate (40 per cent nicotine)	1 pint
Water to make	100 gallons

Lime-sulfur is included for the control of apple scab. Where scale is present, 11 gallons of lime-sulfur may be used, instead of 2½ gallons, in 100 gallons of spray mixture.

Lead arsenate is used for the control of case-bearers, the green fruit-worm, the tent caterpillar, and other chewing insects. It is of value also in the control of apple scab.

Nicotine sulfate is used primarily against the rosy and green aphids and the bud-moth larvae. If the trees have been sprayed with tar-distillate emulsion, the nicotine may be omitted. For the nicotine spray to be most effective against the rosy aphis, it is necessary to delay spraying until nearly all the eggs have hatched. Under normal weather conditions this has taken place by the time the opening leaves have reached the stage indicated, and that is usually early enough for scab control In exceptional seasons, however, apple-scab infection may occur before the aphis eggs have hatched. Under such circumstances an additional early application of 2½ gallons of lime-sulfur and 3 pounds of lead arsenate may be required for scab control, followed later, when the aphids are hatched, by the application of lime-sulfur, lead arsenate, and nicotine.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated for the control of scab and of chewing insects.

Pre-blossom sprays

Lime-sulfur	2½ gallons
Lead arsenate	3 pounds
Water to make	100 gallons

The pre-blossom spray or sprays, applied between the delayed dormant spray and the bloom, are timed primarily for scab control. The points to be considered in timing the applications are: the occurrence of rain periods; the amount of new growth; and the stage of development of the scab fungus. In some seasons two pre-blossom applications are required for effective scab control, especially on extremely susceptible varieties such as McIntosh.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated. If conditions are favorable for severe scab infection, the grower should spray as much as possible, using dust to complete the operation on time.

Calyx spray (When the last of the petals are falling)

Lime-sulfur	2½ gallons
Lead arsenate	3 pounds
Water to make	100 gallons

If redbugs are present, 1 pint of nicotine sulfate should be added to each 100 gallons of the spray mixture.

This spray is applied chiefly to control apple scab and to poison the codling-moth larvae which later enter the blossom end of the fruit.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated. If conditions are favorable for a heavy infection of scab, the grower should spray as much as possible, using dust as a supplementary measure. If redbugs are to be controlled, a separate application of 2-per-cent-nicotine lime dust is indicated.

Summer sprays

In planning a spraying schedule for the summer applications—that is, after the calyx or the special curculio spray—it must be kept in mind that the regulations of the Federal Food and Drug Administration do not permit more than 0.01 grain of arsenic trioxide or more than 0.019 grain of lead per pound of fruit. A tolerance of 0.01 grain of fluorine per pound of fruit is allowed. These requirements may be met either by removing the residue by washing, or by modifying the schedule to keep the residue below tolerance. Washing will necessitate some expense for cleaning; a modification of the schedule to keep the residue below tolerance is likely to result in serious loss from codling-moth and apple-maggot infestation. If the grower is in a position to have his crop washed, he can follow a schedule designed to give adequate protection against these pests. It is at present impossible to suggest a satisfactory schedule for those who cannot wash their fruit. The later sprays may be omitted or the strength of the insecticide reduced; but this is likely to result in heavy losses from codling moth and apple maggot, and will not insure freedom from excessive residue in all cases.

The following formula is suggested for use in orchards where the fruit can be adequately cleaned if necessary:

Lime-sulfur	2½ gallons
Lead arsenate	3 pounds
Water to make	100 gallons

During very hot weather or where frequent very heavy spraying is required for codling-moth control, one of the wettable forms of sulfur may be substituted for the lime-sulfur.

In order to reduce the danger of lead residue, it has been suggested that calcium arsenate be substituted for lead arsenate in the summer sprays. To determine the value of calcium arsenate, the State Experiment Station at Geneva in 1933 conducted extensive experiments in the principal apple-growing regions of New York. It was found that calcium arsenate is less effective than lead arsenate against the codling moth. In moderately infested orchards, however, good commercial control resulted from its use.

In the severely infested orchards of western New York, the control was decidedly inferior to that obtained with lead arsenate.

An important objection to the general use of calcium arsenate is the danger of serious foliage injury. The incidence and severity of this type of injury apparently depends on a number of factors, such as the variety of apple, the vigor of the tree, weather conditions, and the other ingredients of the spray mixture. In 1933 many growers, especially in eastern New York, used calcium arsenate in one or more sprays without appreciable foliage injury. Others, however, found the material decidedly unsafe. In view of the conflicting results obtained in 1933, it does not seem wise at this time to suggest a schedule for the general use of calcium arsenate.

Growers who plan to use calcium arsenate to avoid lead residue should keep the following points in mind. It should never be used alone; 3 pounds of hydrated lime should be added to the spray mixture for each pound of calcium arsenate used. This addition of lime may prevent the foliage injury, or may merely postpone it for a time. McIntosh apples seem to be less liable to injury than do other common varieties; Baldwin, Rhode Island Greening, and Ben Davis are especially susceptible to injury. Weak trees show more injury than do vigorous ones. In view of these facts, it would seem advisable to limit the use of calcium arsenate to the last one or two treatments for the season. In spite of all its limitations, calcium arsenate is the best substitute available for lead arsenate in those areas where the codling moth is not an acute problem.

In some seasons a special spray, applied from a week to ten days after the calyx spray, may be required to control apple scab. The fungicide included in the later codling-moth applications is ordinarily sufficient for scab control during the summer. The first cover spray for the codling moth is usually applied about four weeks after the calyx application, and the second about two weeks later. These cover sprays are applied in order to prevent newly hatched codling-moth larvae from entering the fruit at the side. In seasons when the spring and the early summer are warm, so that the codling-moth larvae of the first brood mature early, an application of spray should be made about the first week in August for control of the second brood.

If there is danger of spray injury to foliage and fruit by lime-sulfur applied during unfavorable weather conditions, a wettable sulfur may be substituted for the lime-sulfur. While injury may result from the use of this material if it is applied during very hot weather, the danger of such injury is somewhat reduced. This substitution is often necessary with Baldwin, which is especially subject to spray injury.

In some localities in the Hudson Valley a special application for control of the plum curculio is often advisable, as directed on page 38. Directions for timing the application for control of the apple maggot are given on page 40.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated.

The same precautions concerning residue should be taken in dusting as in spraying. During prolonged rain periods, it is advisable to make dust applications at shorter intervals than are indicated for spray mixtures. When there is already considerable scab on the foliage, control is made more effective by relying on applications of liquid lime-sulfur spray, since thorough applications of the material will burn out the scab lesions and will

prevent in large measure the formation and spread of summer spores. However, the danger from heavy applications of liquid lime-sulfur during the summer should not be overlooked.

PLANT LICE

Three species of plant lice, or aphids, may appear on the opening buds of the apple: the grain aphis, the green aphis, and the rosy aphis. These three species differ considerably in their life history, their habits, and the type of injury which they cause. The rosy aphis is by far the most important. In western New York serious outbreaks of this pest occur once in three years on an average, but the insect may be injurious for several years in succession. The rosy aphis causes very serious loss by dwarfing and deforming the fruit, rendering it unmarketable. The green aphis is next in importance, but, since it attacks mainly tender, growing shoots, its most serious injury is the dwarfing and deforming of the new growth of nursery stock and young plantings. In occasional years, however, it causes serious injury to fruit and foliage in bearing orchards. The grain aphis, although often appearing in the greatest numbers on the opening buds, causes very little damage to the apple, since it leaves the trees early in the season.

All three of these species of plant lice pass the winter in the egg stage on the bark of the apple. The eggs, about 1/32 inch long, are black, shiny, and elliptical in shape. The grain aphids hatch just as the buds are showing green, and the green and rosy aphids appear a week to ten days later. In normal seasons, all three species have completed hatching by the time the leaves of the blossom clusters are out ½ inch and are beginning to turn back at the tip.

All of the lice that hatch from the eggs are females, and, when mature, are known as *stem mothers*. Soon after hatching, the insect inserts its bristle-like mouth-parts into the leaf and begins to suck out the plant juices. As the young aphid increases in size it molts its skin three times, and after the third molt it is a mature female which in a short time begins to give birth to living young. Reproduction continues in this manner throughout the summer, and no eggs are laid until fall.

Grain aphis

(*Rhopalosiphum prunifoliae* Fitch)

The grain aphis hatches as soon as the buds show green, and is usually the most abundant species. The newly hatched aphids are dark yellowish green, and may be distinguished under a strong lens by the cornicles, which are so short as to appear like low tubercles (figure 1, C). The mature stem mother is yellowish green, with a dark green band extending the full length of the body and expanded laterally along the edges of each segment. The majority of the second generation acquire wings and migrate to their summer food plants without causing any serious injury to the apple. This species lives on grains and grasses until October or November, when males and females are produced. These return to the apple, where the winter eggs are deposited.

Green aphis

(*Aphis pomi* DeGeer)

The eggs of the green aphis hatch at about the same time as or slightly earlier than do those of the rosy aphis. The newly hatched nymphs of this species are dark apple-green in color, and may be distinguished under a lens by their short, cylindrical cornicles (figure 1, A). The mature stem mothers are bright yellowish green, with the cornicles and the tips of the antennae black. The green aphis lives on the apple throughout the season, but many individuals of the second and third generations acquire wings and migrate not only to other apple trees but also to pear, quince, and spiraea.

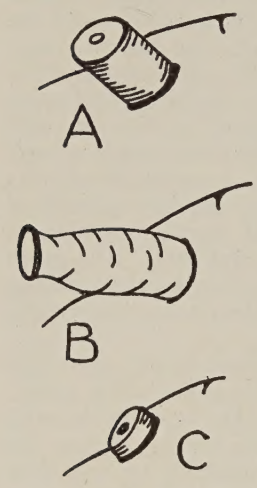

FIGURE 1. CORNICLES OF THE NEWLY HATCHED STEM MOTHERS

A, Green aphis; B, rosy aphis; C, grain aphis
The cornicles are two small tubes projecting from the back of the insect near the hind extremity

In normal seasons, during the early summer the green aphids are reduced to small numbers by the attacks of various insect enemies. Occasionally, during midsummer, weather conditions are favorable for the development of aphids and unfavorable for their enemies. Under such conditions the aphids not only increase to enormous numbers in previously infested orchards, but also develop large numbers of winged individuals which migrate in swarms to other trees that were free from the pest earlier in the season. When this occurs, the insects cause serious dying-back of shoots in nursery stock and young trees. In bearing orchards they cause not only considerable injury to the foliage and the terminal shoots, but also serious damage to the fruit by invading the fruit clusters. Extended feeding of the aphids on the young fruits causes the fruits to be dwarfed and misshapen; if the feeding is less prolonged, it produces a roughened, pitted surface, and sometimes a reddish stippling or spotting of the skin similar to that caused by San José scale. The aphids also cover the fruit and the foliage with sticky honeydew, on which a black, sooty fungus grows, this often staining the fruit so badly as to greatly reduce its market value.

Rosy aphis

(*Anuraphis roseus* Baker)

The rosy aphis is usually by far the most destructive species of aphis that attacks the apple. It is present, at least in small numbers, in most apple orchards in New York, and causes serious damage in one or more localities every year. In some years it is destructive throughout the State.

The newly hatched nymphs are very dark green, and may be distinguished from the other species by the longer cornicles, which are flanged at the tip (figure 1, B). The mature aphids vary considerably in color, but are usually of a dark bluish slate color and are covered with a waxy bloom or powder. In later generations the insects usually take on a pinkish or a rosy tinge.

The stem mothers mature and begin to produce young at about the time the blossoms show pink. The second generation begins to reproduce just as the fruit is setting. The third generation becomes mature about the middle of June, just as the young apples begin their period of rapid growth. At this time representatives of all three generations are producing young simultaneously. The rosy aphis has the habit of clustering on the leaves of the fruit spurs and on the stems of the young fruits, as well as on the fruits themselves. This habit, together with the enormous reproduction of the species, explains how the insect is capable of causing such serious injury. The rapidly forming apples are in a tender condition at the time when the aphids are most abundant. Apples injured by the rosy aphis are dwarfed, deformed, poorly colored, and characteristically puckered at the blossom end (figure 2). Where the young apples have been injured by the aphis,

FIGURE 2. APPLES INJURED BY THE ROSY APHIS

the natural thinning known as the "June drop" does not occur, with the result that the tree is covered with numerous clusters of small, misshapen apples. The feeding of the rosy aphis on the leaves causes them to curl

tightly and roll up diagonally like a cigar wrapper. One or two aphids to a leaf are enough to produce curling. The curled leaves protect the lice not only from heavy rains but also from the spray. Fortunately, the rosy aphis does not stay on the apple throughout the season. The majority of the third and fourth generations acquire wings and migrate to narrow-leaved plantain, where they remain until late autumn.

Control

Two methods of controlling the rosy aphis have been found of value under commercial conditions—spraying with nicotine sulfate, and spraying with tar-distillate emulsion.

Control with nicotine sulfate

In bearing orchards, control measures are directed primarily against the rosy aphis, since this species is by far the most destructive to the crop. At the same time, the measures used against the rosy aphis are equally effective against the early generations of the green aphis, and tend to prevent, or to delay to a considerable extent, summer outbreaks of that species.

The rosy aphis is best controlled by spraying with nicotine sulfate just after the aphids have hatched and while they are still exposed on the opening buds. This is known as the *delayed-dormant period.*

In normal seasons the eggs of this species have completed hatching by the time the leaves of the blossom buds are projecting ½ inch and are beginning to curl back at the tip. But the hatching period varies from year to year, and the time of application of the spray can be accurately determined only by close observation of the aphids on the buds and the unhatched eggs on the twigs. Since the grain and the green aphids are often present in large numbers on the buds before the rosy aphids have appeared, it is necessary to be able to distinguish between the different species in order to know when the rosy aphids have hatched. Spraying too soon results in a waste of nicotine and a failure to control the most dangerous of these species. The newly hatched aphids of the three species are similar in general appearance, but under a lens they can be distinguished by differences in the length and the shape of the cornicles (figure 1).

The spray should be applied as soon as hatching is practically complete. In warm weather, hatching is complete within four or five days after the first rosy aphids have appeared, but cool weather may extend the hatching period considerably. Further delaying of the application involves the danger of scab infection in the event of rain, and makes the spray less effective against the aphids.

Later sprays are ineffective against rosy aphids, because the aphids are then so well protected in tightly curled leaves that they cannot be reached, and because they have increased so enormously in numbers that even if a large proportion could be killed the number remaining would be sufficient to produce a serious infestation.

If all the rosy aphids are killed on the opening buds, the trees will stay clean for the remainder of the season, since this species does not migrate from tree to tree to any appreciable extent.

As a general rule, it is not possible to predict at the delayed-dormant period whether there will be a serious outbreak of aphids, since this depends to a great extent on weather and on other conditions. Under favorable conditions, aphids reproduce so rapidly that even small numbers

at hatching time may result in serious injury later in the season. The use of nicotine in the delayed-dormant spray is therefore rightly regarded as profitable, even in years when rosy aphids are rather scarce at that time. This is particularly true with such varieties as Cortland, Twenty Ounce, Maiden Blush, Rhode Island Greening, and Rome Beauty.

Although the rosy aphis lays its eggs abundantly on McIntosh, this variety is less liable to serious injury than are most other varieties.

Recent experiments have demonstrated clearly that nicotine is by far the most effective and the safest spray material for the control of aphis. Nicotine sulfate is used at the rate of 1 pint to 100 gallons of the spray mixture, and is equally effective whether combined with lime-sulfur 1–40 or with lime-sulfur 1–8.

Oil sprays at ordinary strengths are not sufficiently effective against aphis eggs to be worth while as a dormant or an early delayed-dormant spray, and when used in the delayed-dormant spray against the newly hatched nymphs they have not given so high a degree of control as have lime-sulfur and nicotine sulfate.

Oil emulsions containing 2 per cent or less of oil are ineffective. Drenching the trees with a 3-per-cent oil emulsion at the delayed-dormant period kills a considerable proportion of the newly hatched nymphs, and the protection thus afforded passes with some growers as commercial control. The oil kills the aphids that it actually hits, but it lacks the volatile fumes which make nicotine so effective. It is therefore suggested that, if an oil spray is used, ¾ pint of nicotine sulfate be added to each 100 gallons of the spray mixture as a precautionary measure. In general, the foregoing considerations hold for miscible oils as well. They are equally unreliable for aphis control at dilutions that are safe for foliage and buds, and some of the brands have the further disadvantage of being incompatible with fungicides used for scab control.

The rosy aphis is a difficult pest to control. Even when the proper materials are used at the right time, failure is certain unless the spray is very skillfully applied. Low temperatures and strong winds greatly reduce the effectiveness of the nicotine and make proper coverage difficult; therefore, whenever possible, this application should be made in warm, quiet weather.

The young aphids are very sensitive to cold winds and are constantly moving about on the buds to avoid the wind and to keep in the sunshine as much as possible. For this reason, all sides of the buds must be completely covered at the same operation. If the lee side is left to be sprayed when the wind changes, many of the aphids sheltered there will escape. Complete coverage of the buds can be accomplished only by wetting them from several different angles. This cannot be done by spraying from the tank alone. On very low trees and with favorable winds, complete coverage of the buds may be insured by spraying from the ground only, using a long hose. The operator should walk around and under the tree, directing the spray material against the buds from as many angles as possible. Each branch of the tree should be wet by directing the spray diagonally into the wind as the operator approaches it and after he has passed it. On high trees, complete coverage is best accomplished with the ground lead of hose operated as already suggested, and an additional hose operated from the tank or the tower. The operator on the tank or the tower also should spray

each part of the tree as he approaches it and after he has passed it. Such coverage will require very liberal quantities of spray materials. This system of spraying does not require that the entire tree be covered at one operation, although this may be done if the trees are low and the wind is not too strong. On high trees, where it is not possible to completely cover the tree at one operation, as much of the tree as possible should be sprayed, as previously outlined, and the remainder finished as soon as the wind permits. In some seasons, when the wind does not shift to the desired direction, it may be necessary to "fight" the wind in order to complete the operation on time.

The operator should follow some definite system in spraying, so as to cover all parts of the tree as quickly and as thoroughly as possible. An efficient method used at the New York State Agricultural Experiment Station at Geneva is shown in figure 3.

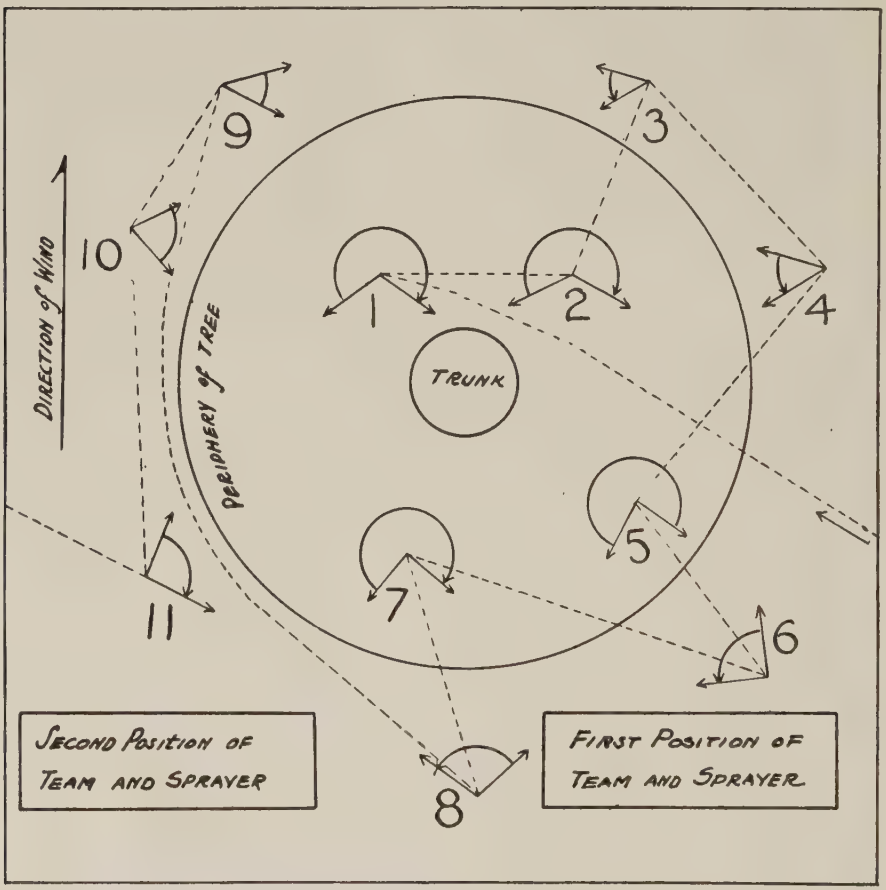

FIGURE 3. DIAGRAM OF A SYSTEM FOR SPRAYING AN APPLE TREE TO CONTROL THE ROSY APHIS

The broken lines represent the path of the men who operate the nozzles, and the numbers indicate the successive stations at which the spraying is done. The straight arrows show the direction in which the spray is thrown at the beginning and at the end of each stop, and the curved arrows represent the general rotation of the nozzles in directing the spray gun

The green aphis in bearing orchards is to a large extent controlled, together with the rosy aphis, by the delayed-dormant spray, since good spraying at this time will kill practically all of the aphids of both species. The aphids can be controlled also by the use of tar-distillate emulsion. These sprays do not insure complete protection from green aphis throughout the season, because, beginning with the second generation, a large proportion of the green aphids are winged, and in years of summer outbreaks they migrate in considerable numbers and infest clean orchards. As a general rule, however, trees receiving a thorough delayed-dormant spray with nicotine sulfate are less often infested by, and suffer considerably less injury from the summer outbreaks of, the green aphis. When summer outbreaks occur, serious damage to the fruit crop may result unless special control measures are used. All suckers and water sprouts should be removed from the trees; the aphids breed on these in large numbers. When green aphids appear in considerable numbers on the terminals of bearing trees, they should be watched closely. As long as they confine their breeding to the terminal shoots and the leaf clusters, the special spray may be withheld in the hope that natural agencies will keep the aphids within bounds. If, however, the aphids invade the fruit clusters, a spray should be applied at once, using nicotine sulfate, 1 pint combined with 3 to 5 pounds of soap in 100 gallons of the spray mixture.

Oil emulsions used as summer sprays for green aphids are ineffective and may cause considerable injury to the foliage.

Control with tar-distillate emulsion

The eggs of aphids may be killed by spraying in the spring, before the buds show gray at the tip, with tar-distillate emulsion containing 2.4 per cent of creosote oil in the diluted mixture.

If the grower is using tar-distillate emulsion for aphis control and desires to keep down the infestation of bud moth as well, the diluted mixture should contain 3 per cent of creosote oil. If the bud-moth infestation is moderate or severe, the diluted mixture should contain 4.5 per cent of creosote oil. (See table 2, page 83.)

APPLE SCAB

(Caused by the fungus *Venturia inaequalis* (Cooke) Winter)

The commonest and most destructive disease of apples in New York is apple scab. The loss caused by scab in commercial orchards in western New York over a period of years exceeds that caused by any other disease or insect. Every fruit-grower knows the tremendous damage to the apple crop caused by scab. It is less well known that, in some years, early scab infection on the fruit pedicels, when not controlled, almost entirely prevents the setting of fruit. Another loss not always recognized is the weakening of the trees following severe leaf infection, a condition which results in the reduction of later crops.

The scab fungus commonly affects the fruit and the leaves, but it may be found also on the leaf stalks, on the flowers, and, rarely in New York, on the twigs.

The first appearance of the scab on the leaves is a dull, smoky area, which is difficult to be seen without careful examination. A little later the

spots become more olive-colored, velvety, and much more noticeable. If leaf infections occur before the leaves of the clusters have rolled back, considerable numbers of these spots will be found on the under surface of the leaves.

The first infections on the fruit may occur on the sepals when only green tips are showing on the fruit buds. These sepal infections resemble closely the leaf infections, and are often overlooked. When sepal infections are present, the scab fungus later spreads from them to the surface of the fruit, resulting in scab spots near the calyx end of the apple. The spots on the fruit itself, regardless of their source, first appear as small, circular, olive-colored areas; but later, as the fungus spreads and the fruit grows, the familiar scabby spots are produced (figure 4), sometimes being accompanied by a cracking of the fruit.

The appearance on the leaf stalks and on the flowers is similar to that on the leaves. The scab spots on the twigs vary with the variety of apple, but often become somewhat swollen, with a blistered or a scurfy appearance.

Apple scab is caused by a fungus which overwinters in the old fallen leaves as partly grown fruiting bodies. These fruiting bodies ripen in the early spring. The date of ripening varies slightly with the variety of apple, but is largely determined by weather conditions. In western New York, in most years these fruiting bodies (perithecia) are ripe and ready to discharge their first spring spores (ascospores) by the time the delayed-dormant spray is applied: that is, when the leaves of the blossom buds are out from ¼ to ½ inch. Rain for a few minutes is sufficient to wet the old leaves on the ground and to cause the shooting of the ascopores to a distance of about ¼ inch from the leaves. Air currents then carry the light spores long distances, and many of them settle on the green parts of the apple trees. This shooting of spores usually continues, during wet weather, for four to six weeks. The supply of ascospores is usually exhausted two weeks or so after the petals have fallen.

If the green tissue is wet when the spore lodges, and remains wet for a sufficiently long time, the spore will germinate and send its sprout or its germ tube into the tissue. The time required for the spore to germinate and grow into the green tissue varies with the temperature. The shortest time required is at temperatures between 60° and 70° F., while much longer periods of wetting are required when the temperature is near the freezing point.

After the fungus has penetrated the leaf or other green tissue, it grows under the cuticle for seven to eighteen days, and then sends up stalks on which the summer spores, or conidia, are borne. These summer spores when dry are firmly attached to the stalks bearing them, but when wet they promptly become detached. They are not blown long distances as are the ascospores from the old fallen leaves. Water is required to loosen the summer spores, which then are washed to new locations and are scattered only so far as the water is splashed or blown. When these summer spores are carried to other leaves or fruit, they germinate and send germ tubes into the tissues to form new spots. This continues during rain periods throughout the summer. When the scabby leaves drop to the ground in the fall, fruiting bodies start to develop in them. These fruiting bodies will go through the winter and will serve to start new scab infections in the following spring.

FIGURE 4. APPLE SCAB ON THE UPPER AND LOWER SURFACES OF LEAVES AND ON THE FRUIT

Control

From a study of the life history of the scab fungus, it would seem that the disease might be controlled by destroying the dead leaves in which the fungus overwinters. Plowing-under the leaves reduces greatly the number of fruiting bodies and of ascospores discharged in the spring. Unfortunately this has not been found to be of much practical benefit, for, with the most

careful work, there are still considerable numbers of leaves left uncovered around tree trunks, along fences, and in other protected places. One tree may have enough leaves under it for 2,000,000,000 spores, so that if 90 per cent were destroyed there still would be enough left to give abundant infections. If it were possible to destroy every leaf in the orchard, there still would be the wind-borne spores from other apple trees to contend with.

The practical method of control has proved to be the covering of the green tissue of fruit and leaves with a protective coating of a material which will prevent the spores from germinating and entering the tissue. The materials found to be most effective for this purpose are sulfur and copper. Sulfur is most commonly used in the form of lime-sulfur spray, wettable sulfur sprays, ground sulfur, and colloidal-sulfur dusts. Copper is commonly used in the form of bordeaux-mixture spray and copper-lime dust. Unfortunately, under New York conditions the danger of injury to the fruit and the leaves of the apple from copper compounds is so great that sulfur compounds have almost entirely supplanted them.

Since the scab fungus spreads only during wet weather, it is essential that the protective coating be applied before rain periods. A considerable degree of scab control may be obtained also, in many instances, by applying liquid lime-sulfur immediately after the rain infection period. Sulfur applied in the form of lime-sulfur or sulfur dust does not wash off during an ordinary rain. Chemical tests have indicated that enough sulfur remains, on the surface covered with either form, to prevent scab infection for twenty days of rainy weather. The reason for frequent applications during the early part of the season is, not to renew the coating on the surface, but to cover the new growth. During the period before blossoming, the apple tree frequently unfolds two or three new leaves in a day and the leaves that are already out increase rapidly in size. Later in the season, growth is much slower and less frequent applications are required.

It is obvious, from a study of the life history of the scab fungus, that the dangerous period is from the time when the fruiting bodies in the old fallen leaves are ripe, until all their spores are shot. This period is usually from the time of the delayed-dormant spray until shortly after the petal-fall application. In most years, the battle against apple scab has been won or lost by the end of this period or two weeks later. If the new growth of leaves and fruit has been protected through the rain periods until there are no more spores from the dead leaves, special applications directed against scab are not needed for the rest of the season. On the other hand, if the trees have gone through a single rain infection period without protection and many of the leaves have become infected, later spraying or dusting will not insure a clean crop no matter how frequently it is done.

It is evident that the success or the failure to control scab is almost entirely dependent on the proper timing of thorough applications in the early part of the season. If an application is not made until after a long rain infection period, failure is almost certain. On the other hand, if an application is made a number of days ahead of the rain period, new growth will develop in the meantime which will be unprotected during the rain. For best results, the spray should be applied just before the rain period.

In western New York, the delayed-dormant spray was of importance in scab control in seventeen of the past twenty-five years.[1] Observations for a

[1]From an unpublished thesis by W. D. Mills, *The Seasonal Development of Apple Scab in Western New York.*

sufficient number of years are not available to determine the relative value of this spray in the Hudson or the Champlain Valley. The limited data indicate a somewhat later development of the scab fungus in relation to the fruit-bud development in those areas. Apparently the delayed-dormant spray is of importance in scab control there in fewer years. This does not mean, however, that this spray may be safely omitted in any part of the State.

The proper timing of the delayed-dormant spray is a very difficult problem. To provide for this, it is necessary to know (1) the stage of development of the scab fungus in the old fallen leaves, (2) the weather forecasts, (3) the development of the apple buds, and (4) the development of the apple aphids, which are controlled by nicotine in this spray. The spray information service of the farm bureaus has been able to ascertain these factors and to properly time the delayed-dormant application. Many growers, however, apply the material before the spray-service warning, and they get poor scab control and no control of the aphids. No exact rule can be given, but usually the leaves of the blossom buds are out from ¼ to ½ inch when this application is made. It is possible that in some years serious sepal infection may occur even before this stage of the buds.

The pre-blossom application or applications, made between the delayed-dormant period and the bloom, present a still more difficult problem. An application during this period is almost always of importance in scab control in all parts of the State. Two pre-blossom applications between the delayed-dormant spray and the bloom have proved to be of great value in several years in western New York. The important considerations in timing the pre-blossom treatment are (1) the weather forecasts, (2) the amount of growth since the last application, (3) the development of the apple buds, and (4) the development of the fruiting bodies of the fungus in the fallen leaves. It is essential to have as reliable a weather forecast as possible, preferably for three days ahead. If much new growth has occurred since the delayed-dormant period, and rains are coming, a cover must be applied even though only a few days intervene. If the clusters of fruit buds are exposed and the bud stems are elongated when the application is made, adequate protection will probably be secured through the blossoming period. On the other hand, if the application is made because of approaching rain when the buds in the cluster are still short-stemmed and closely packed together, a second application will be necessary just before the bloom, to give protection until the petal-fall application. In general, the practice is to delay the application after the delayed-dormant period as long as the weather permits with safety, so that only one pre-blossom application will be made, as close to blossoming as possible. Many growers have failed to control scab because they waited for the full pink stage of the blossom buds, instead of timing the treatments to precede the rain periods.

The calyx application is made as the last of the petals are falling, and is timed by tree development alone. It is usually important in scab control.

A spray or a dust is advisable, in some seasons, about ten days or two weeks after the calyx spray. This is necessary when there are still many scab spores in the old fallen leaves and rains are predicted.

The seasonal control of apple scab thus consists of a delayed-dormant treatment, one or sometimes two pre-blossom applications, a calyx application, and in some years a special scab spray or dust about ten days or

two weeks after the calyx application. A fungicide included in the later applications for codling moth is ordinarily sufficient for scab control during the summer.

For these applications, 2½ gallons of lime-sulfur is used in each 100 gallons of the spray mixture, in combination with lead arsenate for the control of chewing insects, and, when necessary, with nicotine for the control of insects for which the stomach poison is ineffective. This concentration, 2½ gallons of lime-sulfur in 100 gallons of the spray mixture, has been found as effective against the scab fungus as have stronger concentrations. The lead arsenate is known to increase somewhat the fungicidal value of the spray against scab. The addition of lime to the spray mixture has been shown by several investigators to reduce the fungicidal value of the lime-sulfur spray against scab. Lime-sulfur has been found more effective than the milder substitutes in checking the spread of scab from scabby leaves already present on the trees.

A number of wettable sulfur sprays also are used for scab control. The manufacturers' directions should be followed. When dry-mix sulfur-lime is employed, 16 pounds of the material should be used in each 100 gallons of spray, in combination with the necessary insecticides.

When dust is preferred, 90–10 sulfur–lead-arsenate dust is generally used. The dust should be of such fineness that 90 per cent or more will pass through a screen with 300 meshes to the inch. Where less arsenical is required, 95–5 sulfur–lead-arsenate dust is used, and in some cases straight dusting sulfur with no arsenical is employed. With the last-mentioned material, some "fluffer" or filler should be included to prevent agglomeration of the particles in a substance which will not dust well. A number of new dusts containing colloidal sulfur, and others containing some sulfur in the form of polysulfides, are now being tried.

BUD MOTH

(*Spilonota ocellana* Schiffermüller)

The bud moth is present in the majority of orchards throughout New York. Although ordinarily of minor importance, it has during the past five years caused serious injury in orchards along Lake Ontario.

The species passes the winter as small, half-grown larvae in inconspicuous silken cocoons covered with bits of bark and frass and fastened in the crotches of the twigs and around the buds of the smaller branches. These partly grown larvae emerge early in the spring, burrow into the opening fruit buds, and feed on the contents. As the buds expand, the larvae web together the unfolding leaves and feed inside the protecting nest thus formed, injuring both foliage and blossoms (figure 5). They also gnaw into newly formed fruits and cause them to either drop or develop scars somewhat similar to those caused by the leaf-roller. The injured foliage of the nest turns brown, giving the tree the appearance of having been scorched by fire. The larvae sometimes bore into the terminal shoots, causing the tips to die back.

The larvae, which are chocolate brown with head and cervical shield black, become full-grown in late May or June and pupate within the nests. The small, ash-gray moths, with white markings, are present in the orchard from the middle of June until August. Soon after emerging,

the female moths deposit on the leaves their milky white, flat, disk-like eggs, which, except for their smaller size, closely resemble those of the codling moth. The eggs hatch in about a week, and the young larvae feed on the underside of the leaves, skeletonizing them in patches along the midrib and the larger veins and covering their feeding ground with a web of silk. Often, where an infested leaf rests against the surface

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FIGURE 5. BUD-MOTH INJURY TO BLOSSOMS AND LEAVES

of an apple, the larvae will eat out a group of small cavities, resembling codling-moth "stings," in the surface of the fruit (figure 6). In badly infested orchards a large proportion of the crop may be injured in this manner.

In September the half-grown larvae desert the leaves and crawl to the branches, where they form their winter cocoons.

Control

The control of bud moth depends on the thorough application, year after year, of the regular schedule of sprays recommended for the control of rosy aphis, scab, and codling moth.

It has been proved that nicotine sulfate in the delayed-dormant spray is the important factor in bud-moth control. This is usually included at the rate of 1 pint for each 100 gallons of the spray mixture for the control of rosy aphis; where bud moth also presents a problem, nicotine sulfate should never be omitted. In badly infested orchards it may be worth while to increase the amount of nicotine sulfate to 1 quart for each 100 gallons of the spray mixture. At this time the young larvae are migrating from their winter cocoons to the buds, and so are exposed to the action of the nicotine.

FIGURE 6. FRUIT INJURED BY THE SUMMER BROOD OF BUD-MOTH LARVAE

If the grower is using tar-distillate emulsion for aphis control and desires to keep down the infestation of bud moth as well, the mixture should contain 3 per cent of creosote oil. If the bud-moth infestation is moderate or severe, a mixture containing 4.5 per cent of creosote oil should be used. (See table 2, page 83.)

It has been thought that the use of lead arsenate at the rate of 3 pounds in 100 gallons of spray, in the delayed-dormant and pre-blossom applications, is of great benefit in holding the bud moth in check, but recent experiments indicate that its value for this purpose has been overestimated. However, the poison is needed at this time for other insects, and it should not be omitted from these sprays. In orchards where the control of bud moth is a serious problem, effective work against the young larvae on the leaves can be done by applying the codling-moth cover sprays with thoroughness; special effort should be made to spray the underside of the leaves.

CASE-BEARERS

Cigar Case-Bearer (*Coleophora fletcherella* Fernald)
Pistol Case-Bearer (*Coleophora malivorella* Riley)

The cigar case-bearer and the pistol case-bearer are commonly found on the apple throughout the State. They seldom become serious pests in well-sprayed orchards, but often are very abundant and destructive in neglected or poorly sprayed plantings.

Control

Case-bearers are usually held in check by the lead arsenate in the regular schedule of sprays. The pre-blossom sprays are especially effective, and, where case-bearers are causing injury, particular attention should be given to a thorough spray containing lead arsenate when the blossom buds are in the closed-cluster stage.

SCALE INSECTS

The three most important scale insects that attack the apple are the San José scale, the oyster-shell scale, and the scurfy scale.

The insect under the scale is a degenerate, soft-bodied creature. The scale is composed of secreted wax and the skins shed by the insect during its development. The three species mentioned differ markedly in the size, the shape, and the general appearance of the scales. The young scale insects, for a short time after birth or hatching, as the case may be, have legs and eyes, and move about in search of a suitable place for feeding. They then insert their thread-like mouth-parts into the plant tissue and begin sucking out the juices. Soon after settling down, they develop scales, lose their legs, and all except the males remain stationary for the rest of their lives.

San José scale

(*Aspidiotus perniciosus* Comstock)

In recent years the San José scale has increased considerably in abundance, especially in the older orchards, and in many orchards enough of the fruit has been spotted by the scale to hinder the sale of the crop.

In addition to the apple, the San José scale attacks pear, quince, peach, plum, and sweet cherry, but it rarely does any considerable damage to these fruits. Currants are especially subject to heavy infestations.

This scale attacks all parts of the tree, including trunk, branches, leaves, and fruit. When the insects are numerous, they gradually kill the limbs and the branches, and the young insects feed also on the leaves and the fruit. On infested fruit, reddish rings develop around the spots where the scales are attached. These are more commonly grouped about the blossom end. Badly infested fruit is considerably discolored, and sometimes is stunted and misshapen.

The scale of the full-grown female is round, about the size of a pinhead, and grayish in color with a central dark spot. In bad infestations these scales are crowded together and resemble a grayish, roughened, scurfy deposit on the bark. The scales of the young insects are smaller than those of the adult, and are black.

Although the insects are present in all stages on the trees in the fall, all perish during the winter except a small proportion of the partly grown young. These complete their development in the spring, and the mature females begin to give birth to living young in the latter part of June. In a cool season with a late spring, the scale does not begin to breed until late, and under these conditions only one full brood and a partial second brood are able to develop before cold weather. Each female gives birth to between 100 and 200 young. The pest can multiply rapidly when conditions are favorable.

Control

The standard treatment for the control of the San José scale is thorough spraying with lime-sulfur at the rate of 11 gallons to 100 gallons of spray. This spray is usually applied at the delayed-dormant period, when by the addition of lead arsenate and nicotine it can be used to successfully combat, in one operation, scale, scab, aphis, and certain chewing insects.

When the scale is incrusted on rough-barked trees, better control is obtained by spraying with a lubricating-oil emulsion containing 3 per cent of actual oil. Miscible oils may be used according to manufacturers' recommendations. The lubricating oil has an advantage over the miscible oil in that it can be safely used with a fungicide and can be used with greater safety after the buds have started. Sodium-sulfide dusts have not proved sufficiently effective against scale to be a worth-while control measure. Dry lime-sulfur is less effective than liquid lime-sulfur, even when used at dilutions giving equivalent total sulfur content, because a greater proportion of the sulfur is not in the more active polysulfide form. While a sodium-sulfur spray compares favorably with lime-sulfur in its effect on the scale, it is little used because of the danger of its burning the foliage, especially when combined with lead arsenate.

Tar-distillate emulsions are not effective against the San José scale except when they contain petroleum oil, and then their efficiency against this insect depends on the percentage of petroleum oil present. Under certain conditions the lubricating-oil emulsion can be combined with the tar-distillate emulsion. (See tables 3 and 4, page 83.)

Many of the well-sprayed orchards in New York are now relatively free from scale and therefore do not require the strong, or scale-strength, dilution of lime-sulfur, 11 gallons in 100 gallons of the spray mixture. In these orchards the lime-sulfur in the delayed-dormant spray may well be reduced to 2½ gallons in 100 gallons, as is used in the later sprays. In orchards where scale spots appear on the fruit, however, the lime-sulfur should be increased to 11 gallons in 100 gallons of the spray mixture, or an oil spray may be used.

Oyster-shell scale

(*Lepidosaphes ulmi* Linnaeus)

The oyster-shell scale is sometimes abundant enough on neglected apple trees to weaken the trees and even to kill the branches, but it is of no importance in well-sprayed commercial orchards. It is more likely to be troublesome in the cooler climate of the northern counties of the State. It is not nearly so dangerous as the San José scale, because there is only one generation a year and the species is much less prolific. The mature

female scale is about ⅛ inch long and closely resembles an oyster shell in form. This species winters over in the egg stage beneath the old scales, and the young hatch in May or June.

Control

The oyster-shell scale is controlled by the measures recommended for the San José scale, or by spraying with tar-distillate emulsion containing 3 per cent of creosote oil in the diluted mixture. (See tables, page 83.)

Scurfy scale

(*Chionaspis furfura* Fitch)

The scurfy scale very rarely causes injury in well-sprayed orchards. The full-grown female scale is about ⅛ inch long, and is flat, pear-shaped, and grayish white in color. When the insects are numerous they give the bark a scurfy appearance. The life history is similar to that of the oyster-shell scale.

Control

The scurfy scale can be controlled with a dormant application of a 4-per-cent lubricating-oil emulsion, or by spraying with a tar-distillate emulsion containing 3.6 per cent of creosote oil in the diluted mixture. (See table 2, page 83.)

FRUIT-TREE LEAF-ROLLER

(*Archips argyrospila* Walker)

The fruit-tree leaf-roller is present in varying numbers in practically all apple and pear orchards in the State. Although it is not especially injurious from year to year in the majority of orchards in any locality, it may suddenly become one of the most serious pests with which the grower has to contend.

This insect passes the winter in the egg stage. The eggs are usually laid on the smaller twigs and on the fruit spurs, in small, oval, flat, grayish or brownish patches, about ¼ inch in diameter and containing, on the average, about 55 eggs. The egg masses are protected by a smooth, varnish-like substance, which so closely resembles the bark in color that the unhatched masses are difficult to detect. Hatched egg masses are more conspicuous, the exit holes of the larvae in the bleached white varnish suggesting a colander, or strainer.

In New York, the eggs normally start hatching when the blossom buds of Rhode Island Greening apples are just beginning to show pink. Individual egg masses usually complete hatching within a few days, but the hatching period for the whole brood extends over a period of two weeks or longer, depending on the season. The young caterpillars are about $\frac{1}{16}$ inch in length, and are of a light green color with the head and the cervical shield black.

The caterpillars cause several types of injury. The first indication of their presence is the "ragging" of the leaves at the tip of the terminal shoots (figure 7). The extent of this type of injury is a good indication of the number of leaf-rollers present and the danger of fruit injury. Just before blossoming time the caterpillars web together the leaves and the

blossom buds of the opening clusters, and feed within the nest thus formed, often destroying large numbers of blossoms by chewing off the stems. As the young fruit is forming, the caterpillars first devour the calyx lobes and

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FIGURE 7. "RAGGING" OF TERMINAL FOLIAGE OF APPLE CAUSED BY THE LEAF-ROLLER

later eat out large, irregular holes in the fruit. The most seriously injured fruits soon drop, while those less severely injured remain on the tree but bear large, brownish, corky scars which render them misshapen and unmarketable (figure 8). Although the injury to the fruit itself is the most conspicuous damage caused, the destruction of fruit buds and foliage also may be severe.

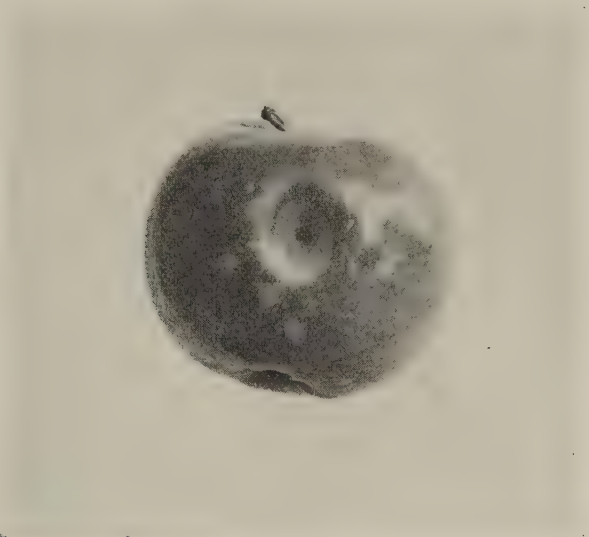

FIGURE 8. FRUIT INJURED BY THE FRUIT-TREE LEAF-ROLLER

The caterpillars are often found resting in rolled leaves adjacent to fruit, or in nests containing injured fruits and leaves webbed together. When disturbed, they escape with a rapid, wriggling motion and spin down on a thread of silk.

The caterpillars become full-grown in three to six weeks and are then about 1 inch in length. They transform to brown pupae within a rolled leaf, and in about twelve days emerge as moths. The moths have a wing expanse of ¾ to 1 inch, and the front wings are mottled with various shades of rich brown and yellowish white.

The moths begin egg-laying soon after emergence, and most of the eggs are laid by the last of June. The eggs do not hatch, however, until the following spring, and so there is only one brood each year.

Control

The fruit-tree leaf-roller is not satisfactorily controlled by the regular schedule of sprays, and special control measures are necessary wherever the insect is causing enough damage to warrant their use.

The leaf-roller can be attacked in either the egg or the caterpillar stage, and the method employed depends entirely on the degree of infestation. This can be estimated by the extent of injury to the crop of the preceding year, or, less readily, by an examination of the trees for egg masses. Experience indicates that when the crop at picking time shows 10 per cent

or more of injury from leaf-roller, it will probably be necessary and worth while to use an oil spray in the following spring to kill the eggs. Where the injury is less than 10 per cent, it is usually more economical to rely on careful and well-timed applications of lead arsenate.

Arsenical sprays

The control of leaf-roller by means of arsenicals requires the use of extra sprays and heavier dosages of lead arsenate than are included in the regular schedule. With light infestations, injury from this insect can be largely prevented by increasing the amount of lead arsenate in the regular pre-blossom and calyx sprays to 5 pounds in 100 gallons of the spray mixture, and spraying very thoroughly.

With heavier infestations, one or two extra applications are necessary. The young, newly hatched larvae are much more susceptible to poison than when they are older, and the object of spraying is to keep the rapidly developing new foliage covered with poison throughout the hatching period. This requires an application when the individual blossom buds are separating in the cluster, a spray just previous to blossoming, the calyx spray, and an application about a week later. While this schedule may be fully as expensive as a special oil spray, it affords extra protection from scab as well as control of leaf-roller.

Oil sprays

Severe outbreaks of leaf-roller are best controlled by an effective oil spray to kill the eggs before they hatch in the spring. The efficiency of the oil spray is extremely variable, depending on the type of oil used, the time of spraying, and the thoroughness of application.

Commercial or proprietary miscible oils are variable in efficiency. The results of numerous tests in New York and other States indicate that, at recommended strengths, some brands are effective while others are practically worthless. Some are ineffective even at greatly increased strengths. If commercial miscible oils are used, it is best to follow the directions of the manufacturer.

Commercial lubricating-oil emulsions, in general, give satisfactory control. Some brands contain about 66 per cent of oil and should be used at the rate of 9 gallons to 100 gallons of the spray mixture.

Homemade cold-mixed lubricating-oil emulsions are effective, safe, and considerably cheaper than most of the commercial oil preparations. Diamond Paraffin oil is used at the rate of 6 gallons to 100 gallons of the spray mixture. This is readily mixed in the spray tank according to directions given on page 81. It is important that the spray material be kept violently agitated in the spray tank.

Whatever the type of oil used, it should be applied as the buds are swelling but not after green tissue has begun to show at the tip. If applied later it is very likely to cause injury, and if applied earlier it is less effective against the eggs, since these become progressively more susceptible as they near the hatching stage.

Oil sprays, to be effective, must be very thoroughly applied, with plenty of pressure and not too fine a spray. Large trees should be sprayed from both the tank and the ground, for only those egg masses are killed that

are thoroughly covered with spray. Contrary to general opinion, oil sprays do not spread to any extent after being applied.

Even with very careful spraying and the most effective materials, some of the egg masses escape and give rise to a considerable number of larvae. The oil spray should be followed by thorough applications of the increased dosage of 5 pounds of lead arsenate in the pre-blossom and calyx sprays, to kill these young caterpillars.

APPLE-TREE TENT-CATERPILLAR

(*Malacosoma americana* Fabricius)

Although in years of abundance the apple-tree tent-caterpillars may defoliate neglected and unsprayed apple and peach trees, they are never of importance in well-sprayed orchards.

Control

The caterpillars hatch as the buds are opening. Lead arsenate at the rate of 3 pounds in 100 gallons of the spray mixture, included in the delayed-dormant spray, gives excellent control.

EUROPEAN RED MITE

(*Paratetranychus pilosus* Canestrini & Fanzago)

The European red mite passes the winter in the egg stage on the under surface of small branches of trees, in crevices and crotches of fruit spurs, and on roughened areas on the bark of the larger limbs and the trunk. The eggs are small, spherical, and reddish in color, and when numerous they resemble a coating of brick dust. Usually they begin to hatch when the blossom buds first show pink, and have completed hatching by the time the petals have fallen. The newly hatched mites crawl to the leaves and begin to feed. They feed mainly on the underside of the leaves, piercing the surface with their thread-like mouth-parts and sucking out the plant juices.

When the mites are numerous, they cause the leaves to turn yellow and sometimes to fall prematurely. Baldwin is the variety most commonly attacked, while Rhode Island Greening and McIntosh are seldom injured.

Control

In most orchards throughout the State, satisfactory commercial control of the European red mite is obtained by the regular schedule of sprays containing lime-sulfur 1–40. Although lime-sulfur has little effect on red-mite eggs, it is very effective against the mites themselves. The pre-blossom and calyx sprays are especially important, since they kill a large proportion of newly hatched mites before these have begun to lay eggs.

Dry-mix sulfur-lime, wettable sulfur, and sulfur dusts have very little effect on red mites; and where these materials are used in place of liquid lime-sulfur, especially in the pre-blossom and calyx applications, the species is likely to become troublesome.

Red-mite eggs are readily killed by spraying with a 3-per-cent lubricating oil emulsion or with miscible oils at the usual strength.

CODLING MOTH

(*Carpocapsa pomonella* Linnaeus)

The codling-moth caterpillar is, on the whole, the most serious pest of apples in New York. Not only does it cause practically all of the familiar wormy apples which are almost a total loss to the grower, but it also produces serious damage in the form of stings, or small shallow cavities, which throw affected apples out of the better grades.

The species passes the winter as full-grown larvae in tough silk cocoons lining small cavities beneath flakes of bark on the tree, in crotches, crevices, and pruning scars on the trunk, and in dead, punky twigs, sticks, and débris on the ground. Numbers of the larvae winter over in crevices in the floor, the siding, and the bins of packing houses, cider mills, or other places where apples have been stored at picking time. The larvae are pinkish or whitish in color, and about ¾ inch in length. With the advent of warm weather in the spring, the larvae transform inside their cocoons to brownish pupae about ½ inch long. They remain in this stage for three to four weeks and then change to moths. The moths have a wing spread of about ¾ inch. The front wings have the general appearance of watered silk, and are marked near the tip with a coppery brown spot bounded on the inside by a chocolate-colored band. The moths are active mainly throughout the twilight period on warm evenings. They are not strong flyers, the majority settling down within 200 to 300 feet of the place of emergence.

The first appearance of the moths and the length of the emergence period are influenced by seasonal temperature, and therefore vary somewhat from year to year. The emergence of first-brood moths extends over a period of about six or seven weeks, beginning shortly after the petals have fallen and reaching a peak about four weeks later. The early moths come from cocoons in warm, sheltered situations. Some of the moths from buildings and packing-houses may emerge from one to three weeks later than does the brood in the orchard.

The female moth deposits her flat, disk-shaped, scale-like eggs on the leaves and on the surface of the fruit. The eggs are smaller than a pinhead, are whitish in color, and are almost transparent at first but later show a reddish ring, and, just before hatching, a black spot, which is the head of the larva.

Temperature and weather conditions have a very important effect on egg-laying. The moths are active in egg-laying only on clear evenings when the temperature ranges above 60° F. If the weather is favorable, the moths begin to lay eggs within three or four days after emergence. With continued favorable weather, egg-laying starts about a week after the petals have fallen and is heaviest about four weeks later, or soon after the maximum emergence of moths. Periods of cool or stormy weather may delay the start of egg-laying or interrupt it for a time, so that the egg-laying and egg-hatching periods may be irregular in some years.

The time required for the eggs to hatch depends somewhat upon the temperature, but it averages about a week. The newly hatched caterpillars are about $\frac{1}{16}$ inch in length. Caterpillars hatching from eggs on the leaves often crawl to the underside of the leaves and feed slightly before proceed-

ing to the fruit. Caterpillars hatching on the fruit usually begin at once to search for suitable places to enter.

Many of the early-hatched caterpillars of the first brood enter through the calyx cup, or blossom end, of the fruit. If they are not killed by poison in the calyx cup, they eat their way to the core. The greater number of the later-hatched caterpillars enter the fruit through the side. They prefer to enter either where an apple touches another fruit or a leaf, or where an insect injury, a puncture, or a russeted area makes entrance easier. Many of these "side-worm" caterpillars cause a type of injury known as *codling-moth sting* (figure 9). A sting results when a larva, after having eaten out a shallow cavity under the skin, either finds the food unpalatable and deserts the burrow to try another point of entrance, or dies from the effect of the poison that it has obtained while making an entrance. While this type of injury is common throughout the State, it is especially serious in a narrow strip bordering the south shore of Lake Ontario.

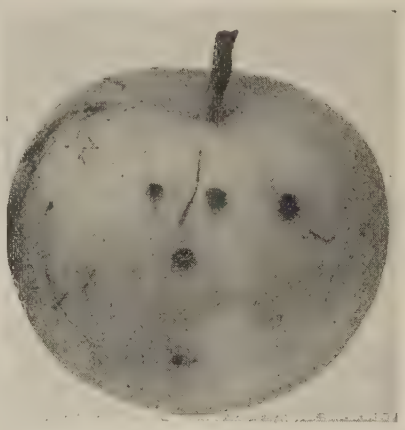

FIGURE 9. CODLING-MOTH STINGS AND SIDE ENTRANCES

A few of the first-brood larvae, entering the side of the fruit late, find the apple sufficiently developed and burrow directly to the core.

The time spent by the larvae in the fruit varies considerably, but averages about thirty days for the first brood and three weeks for the second. When nearly full-grown, the larvae burrow to the surface and keep the opening plugged with excrement until they are ready to leave the fruit. The full-grown larva is about ¾ inch in length, and is pinkish white in color with the head dark brown and the thoracic and anal shields lighter brown.

The greater number of the first-brood larvae leave the fruit before it falls, and crawl down the branches until they find a suitable place for spinning a cocoon. A considerable proportion of the larvae from fallen fruit spin their cocoons in sticks and débris on the ground. After making the cocoons, the larvae may do one of two things: they may remain in the larval condition until the following spring, or they may change to pupae in about a week. In the latter case these summer pupae transform in about ten days to a brood of moths which lay eggs for the second generation. In New York, only some of the larvae spinning cocoons before August 1 transform in the same season, and practically all the larvae that become mature after that date hibernate. The abundance of the moths of the second brood depends on the forwardness or the backwardness of the season. If May or June is backward, egg-laying will be delayed so that very few codling-moth caterpillars will have reached maturity by August 1, and consequently very few moths will be produced in that season. If, on the other hand, May or June is early, a greater proportion of the caterpillars will become full-grown before August 1, and the number of the

second-brood moths will be considerably greater. In western New York the second brood is less than a fourth the size of the first brood, while in the Hudson Valley the second brood is relatively larger. A larger proportion of second-brood caterpillars enter the fruit at the side than is the case with the first brood, and most of these burrow directly to the core. Only a small proportion of them cause shallow stings like those made by the first brood.

Control

In the past the codling moth has been satisfactorily controlled in most parts of the State by spraying with lead arsenate. Except for the residue problem, this arsenical is the most satisfactory for use on apples under New York conditions. The most promising substitute for it is calcium arsenate, discussed on pages 7–8. Under New York conditions it is the practice to apply the poison in combination with a fungicide, usually lime-sulfur, for the control of apple scab.

The first spray for the control of the codling moth, using 3 pounds of lead arsenate to each 100 gallons of the spray mixture, should be applied when the last of the petals are falling. At this time there is a period of three to eight days, depending on the apple variety and the season, when the calyx lobes are expanded and it is possible to place the poison in the calyx cavity. As the fruit starts to grow, the calyx lobes close over this cavity and prevent the poison from washing away. The caterpillars that later attempt to enter the fruit at the blossom end are poisoned in the calyx cavity before they can cause injury.

The difficulty of controlling the codling moth differs greatly in different parts of the State. In some areas, commercial control can be obtained in the normal season by applying the calyx spray and two cover sprays. Along Lake Ontario there are some regions where four cover sprays are necessary. An intermediate situation obtains in the Hudson Valley and in certain places in the Finger Lakes Region. These facts should be kept in mind when adopting a spraying schedule for the control of this pest in any locality.

The object of the cover sprays is to keep the fruit covered with the poison throughout the period when the eggs are hatching, so as to kill the young larvae that attempt to enter through the side. For the control of the first brood, two cover sprays are usually enough except in certain areas along Lake Ontario, where three may be found necessary in some seasons. One or two sprays, usually applied in August, are advisable in some seasons to prevent injury from the second brood. If special care is taken in applying the sprays for the first brood, the control of the second brood will be greatly simplified and the August application may not be necessary.

It can be readily seen that, since the timing of the cover sprays depends on the time of egg-hatching, and since these dates are different for the various fruit districts of the State and vary somewhat from year to year in the same locality, it is very important to have reliable information on the seasonal development of the codling moth. In most of the counties where fruit is grown extensively, this information can be obtained through the local farm-bureau spray information service.

The cover sprays must be applied thoroughly as well as at the right time. The fruit and the foliage should be well covered with the poison. If this is done, many of the caterpillars hatching on the leaves will be poisoned

before they are able to reach the fruit. Caterpillars reaching the fruit and those hatching on the fruit will be killed while entering it. In badly infested orchards these sprays will not entirely prevent stings, since some of the caterpillars will be able to eat out a shallow hole before they die from the effects of the poison. But thorough spraying year after year will reduce the number of moths in an orchard. For this reason, even light crops of fruit should be thoroughly sprayed and not allowed to become wormy. Odd trees near the orchard should be sprayed also, and near-by packing-sheds or apple-storage buildings should be screened at doors and windows, since large numbers of moths may emerge from such places and infest the orchard. Moths from such locations may emerge from one to three weeks later than do the moths in the orchard, and may attack the fruit when it is not well protected by the sprays timed for the orchard brood.

In severely infested orchards where satisfactory control cannot be obtained by thorough applications of 3 pounds of lead arsenate in 100 gallons of the spray mixture, the efficiency of the treatment may be increased by doubling the quantity of lead arsenate, but this increases the danger of residue.

Another method that has been found useful in very severe infestations is the use of summer oils with the lead arsenate. A combination of 2 pounds of lead arsenate with 1 quart of summer oil in 100 gallons of the spray mixture increases the efficiency of the lead arsenate by building up a heavier and more weather-resistant spray deposit. If the amount of oil is increased to 3 to 4 quarts, the spray will be of still more value because of the ovicidal properties of the oil. The objection to the use of oil is that it cannot be combined with sulfur sprays nor applied on fruit or foliage that retains sulfur residue, especially lime-sulfur. If oil sprays are to be used, "Coposil" shows some promise as a fungicide for the preceding application. This material appears to be somewhat safer than other copper compounds to combine with oil if the use of a fungicide is necessary. The use of 1 quart of oil with the lead arsenate is suggested for the first-brood sprays only to avoid the difficulties in the removal of spray residue. For the same reason, the 3- to 4-quart strength should be used only in the July cover sprays.

To avoid residue on early-ripening varieties, such as Duchess and Wealthy, lead arsenate may be used in the first cover spray, followed by two applications of 1 pint of nicotine sulfate and 1 gallon of summer oil in water to make 100 gallons of spray.

As a supplementary control measure, banding, preferably with chemically treated bands, is of value in reducing the codling-moth population. The rough bark should be scraped from the trunk and the larger branches before the bands are placed in position. Banding is useful only in orchards which are heavily infested and in which control by thorough spraying has been found difficult. The chemically treated bands should not be used on young, smooth-barked trees, because of the danger of injury. The bands should be in place by July 1.

APPLE REDBUGS

Bright Apple Redbug (*Lygidea mendax* Reuter)

Dark Apple Redbug (*Heterocordylus malinus* Reuter)

Redbugs are important pests of the apple throughout the State except in the area south of Lake Ontario and north of the "Ridge," where they

rarely cause injury. The infestation is seldom general in any fruit district, being usually confined to occasional orchards or to certain varieties of apples. While any variety may be attacked, Rhode Island Greening and Northern Spy are especially susceptible to injury.

There are two species of redbugs, the bright apple redbug and the dark apple redbug. The two species are closely related and resemble each other in habits and life history. The bright apple redbug is by far the more abundant and injurious of the two, and practically all of the serious commercial damage is caused by this species.

Both species pass the winter in the egg stage in the bark of the smaller branches of apple trees. The eggs of the bright apple redbug begin to hatch when the earliest blossom buds are showing pink, and continue hatching through the blossoming period.

The newly hatched nymphs are about $\frac{1}{16}$ inch in length. The nymphs of the bright apple redbug may be distinguished by their brighter red color, by having the body covered with fine, short, black hairs, and by the lack of dusky markings on the thorax. Both species pass through five immature stages and develop wings at the fifth molt.

The newly hatched nymphs at once attack the tender young leaves of terminal shoots and the new growth on lateral shoots and spurs (figure 10). By means of their bristle-like mouth-parts they pierce the leaf tissue

FIGURE 10. FOLIAGE INJURED BY THE REDBUG

and suck out the plant juices. Injured leaves soon develop clusters of conspicuous reddish dots marking the feeding punctures of the nymphs. These injured tips are often the first indication of the presence of redbugs in an orchard. The insects themselves are very wary and difficult to detect among the unfolding leaves. The nymphs may live on the foliage until they are full-grown, but they usually leave the shoots to attack the fruit soon after it has set. When very young fruit is attacked, the bristles of the bugs penetrate to the core. Many of the injured fruits fall to the ground or dry up and cling to the trees. Those that remain become gnarly and deformed, owing to the fact that the punctured spot fails to develop, while the surrounding fleshy tissue grows out around it, forming a deep pit with the puncture at the center extending as a hard, corky line to the core (figure 11). Punctures made later, after the fruit has become too large for the insect to reach the core, may develop either into shallow pits or into peculiar irregular, russeted areas. The dark apple redbug causes much less injury than does the other species, because it hatches earlier and feeds largely on the leaves. The adults of both species feed to some extent on both the fruit and the foliage, and deposit their eggs during June or July.

FIGURE 11. AN APPLE SHOWING TYPICAL REDBUG INJURY

Knotty apples are caused also by curculio punctures and by aphis injury. Redbug injury may be distinguished from the injury caused by the plum curculio by the fact that no tissue is removed; the juice is merely sucked out, causing a smooth depression in the fruit. The feeding and egg-laying punctures of the curculio cause characteristic scars. Aphis injury is characterized by a puckering about the blossom end of the fruit, which does not appear in typical redbug injury.

Control

The most practical method of controlling redbugs is by the use of nicotine sulfate, 1 pint in 100 gallons of the spray mixture, added to the calyx spray.

In spraying for redbugs the utmost thoroughness is necessary. The insects are killed only when the spray actually hits them or drenches the foliage in the immediate vicinity. To be effective, the spray should be applied on a warm day, when the young bugs are more active; in cool weather they often secrete themselves in the curls of the unopened leaves, where it is impossible to reach them.

Dusts containing 2 per cent of nicotine have been used successfully against the redbugs. Dosages of 3 to 4 pounds are required for a moderate-sized tree, and the dust should be applied on warm, still days. The cost

of dusting is much higher than that of spraying, and the average fruit-grower will find the spray applications much more satisfactory and economical.

THREE RUST DISEASES OF THE APPLE

Apple Rust (*Gymnosporangium juniperi-virginianae* Schweinitz)

Hawthorn Rust (*Gymnosporangium globosum* Farlow)

Quince Rust (*Gymnosporangium germinale* (Schweinitz) Kern)

The three rust diseases of apple are caused by three fungi which live during a part of their lives on the red cedar and during the remainder largely on the apple, the hawthorn, and the quince, respectively.

Both the apple and the quince rust cause direct and serious losses by infections on the apple fruit, while the apple and the hawthorn rust are occasionally destructive on apple foliage. Both types of injury have been largely confined to the Hudson Valley, where red cedars are abundant. The bright orange-colored spots of the apple and hawthorn rusts on the apple leaves are very conspicuous; the hawthorn-rust spots are somewhat the smaller.

The apple-rust spots on the fruit are orange in color, and the small cups of the apple-rust fungus may be seen on the spots when mature. The quince-rust spots on the apple fruit are sunken and are dark green in color, and the tissue below the spots is killed. The small cups of the rust fungus are absent in fruit affected with the quince rust.

The apple rust and the hawthorn rust form their fruiting bodies on the red cedar in the form of cedar apples. These apples, or galls, of the two rusts are similar in appearance, but those of the apple rust are more regular in outline than those of the hawthorn rust, and the surface is covered with circular depressions much like those on a golf ball; the apples of the hawthorn rust are more irregular in form, and do not show the regular arrangement of circular depressions. When the cedar apples are wet in the spring, yellow gelatinous horns protrude from them, these being long and tapering in the case of the apple rust and shorter and more wedge-shaped in the case of the hawthorn rust. The quince rust does not form the galls, or cedar apples, on the cedar, but fruits in cankers on the twigs, the limbs, or the trunk of the cedar.

The apple rust has long been known as a serious disease of apple fruits, especially on the more susceptible varieties such as Wealthy. The quince rust is serious on such varieties as McIntosh, Delicious, and Winesap.

Control

The most effective control consists in the eradication of red cedar for a distance of at least one-half mile from apple trees.

When cedar eradication seems impracticable, the application of fungicides is the most promising alternative. Data are very limited, but it appears likely that a considerable reduction of fruit infections may be expected from applications of lime-sulfur during the apparently limited period when the fruit is susceptible. More experimental work is being done to establish the point, but it appears probable that the susceptible period for the apple fruit is close to the time when the petals fall.

BLACK ROT

(Caused by the fungus *Physolospora obtusa* (Schw.) Cooke)

Black rot attacks the bark and the leaves of the apple, as well as the fruit. On the bark the disease is called *black-rot canker* and *New York apple-tree canker*. On the fruit it is called *black rot*, *ring rot*, *blossom-end rot*, and *brown rot*. On the foliage it is usually called *frog-eye*, although it is known also as *leaf spot* and *brown rot*.

This disease is of more importance economically as a leaf spot and as a canker than as a rot of the fruit. In this State, the varieties Baldwin, Rhode Island Greening, and Twenty Ounce show spotted foliage most commonly. Twenty Ounce is by far the most susceptible of all the varieties to the canker form, but Esopus Spitzenburg, Baldwin, Wagener, Rhode Island Greening, and Tompkins King also are susceptible to cankers.

In severe attacks of "frog-eye," defoliation may occur before harvest; in slight attacks the loss is negligible.

The annual loss of fruit in New York due to the death of cankered limbs from black-rot canker was estimated some years ago by a careful worker at not less than $750,000. The area where this trouble is most severe is that bordering Lake Ontario in western and central New York.

Control

For leaf spot, lime-sulfur, 1–40, has proved to be quite as effective as bordeaux mixture. Dusting with sulfur also is effective. Summer applications are effective against this disease, since most of the leaf infection occurs during the two or three weeks after the petals have fallen.

The effectiveness of applications of fungicides for canker prevention is not proved. However, the decided decrease of canker injury in the State since the general adoption of lime-sulfur spraying leads to the belief that these applications are of value. Systematic cutting-out of cankers and removal of mummied fruit are valuable methods of control.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 68)

In parts of the Hudson Valley the plum curculio is one of the most serious pests of the apple. This is because the numerous stone walls, hedgerows, and woodlots adjoining the orchards serve as ideal winter quarters for the beetles.

The apples are injured by the feeding and egg-laying punctures of the adults and by the burrowing of the grubs. Many of the injured apples fall to the ground, while those that remain on the tree develop D-shaped russeted scars (figure 12) and are often rendered knotty and unmarketable.

The overwintered beetles begin to attack the fruit soon after it has set, and are capable of causing extensive injury in a very short time. Although both feeding and egg-laying may continue for a considerable period, egg-laying is most intensive during the first few weeks. The new generation of beetles, appearing in August, sometimes injure the fruit by their feeding punctures before going into hibernation.

Control

The calyx spray has some influence in reducing curculio injury. If the injury is likely to be serious, a special curculio spray should be applied about a week or ten days after the calyx spray, using 3 pounds of lead arsenate in 100 gallons of the spray mixture. The first cover spray for the codling moth, usually applied about three weeks after the calyx spray in the Hudson Valley, is of some value in controlling the curculio. Cur-

FIGURE 12. SCARS RESULTING FROM EGG-LAYING PUNCTURES MADE BY THE PLUM CURCULIO

culio injury is often localized in certain parts of an orchard near hibernating shelter. In such cases the special sprays may be applied only to that part of the orchard where they are needed.

APPLE MAGGOT

(*Rhagoletis pomonella* Walsh)

In the Hudson Valley and Lake Champlain regions, the apple maggot, or railroad worm, is one of the most serious pests of the apple and is present in many orchards. In western New York the insect may cause serious trouble, especially in crops intended for export. All apple varieties may be attacked, but early-harvest and early-fall varieties are especially subject to injury. Of the late varieties, Fameuse, Jonathan, and Northern Spy are the most liable to attack. The apple maggot occasionally infests plums also.

The adult of the apple maggot is a black-bodied fly slightly smaller than the house fly (figure 13). The transparent wings are crossed by four dusky bands. The thorax is black, with two fairly distinct white bands extending lengthwise and a white spot at the rear. The female is larger than the male, and has four white bands across the abdomen while the male has only three.

The flies begin to emerge from their overwintering puparia in the ground during the latter half of June. They continue to emerge until early August,

and, since they may live for a month or longer, a few late-emerging individuals may be found in the orchard until early September.

The flies do not begin to lay eggs until about a week after emerging. They are readily found on bright days, moving about and sucking up drops of moisture, gums, juices, or almost any material present on the surface of the leaves or the fruit. Particles of solid material are dissolved by means of saliva secreted through the mouth-parts of the flies.

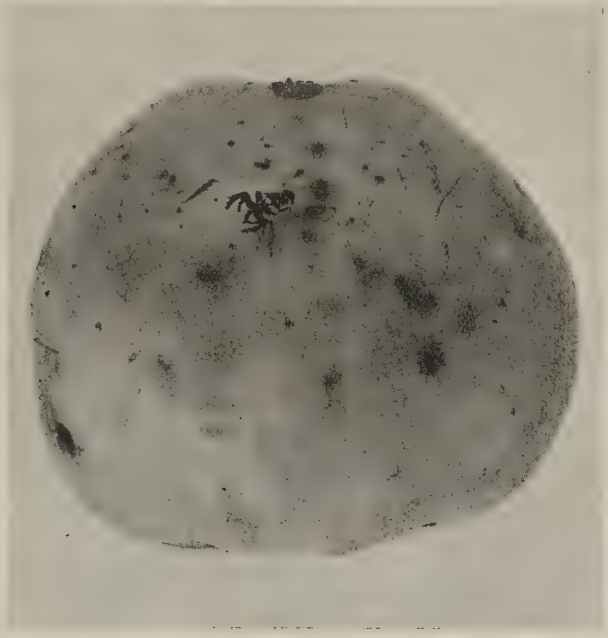

FIGURE 13. APPLE-MAGGOT FLY AND EGG-LAYING PUNCTURES

The female deposits her minute whitish eggs singly, in the pulp of the apple, through small punctures which she makes in the skin with her sharp ovipositor. A large number of eggs may be deposited in a single fruit, and fruits of late varieties become much dimpled and pitted as a result.

The eggs hatch in four to six days, and the young maggots begin at once to tunnel through the fruit in all directions. At first the track left by a maggot is faint, but, as the fruit begins to ripen and soften, the maggot grows rapidly and leaves a broad brownish trail. Badly infested fruits often fall to the ground early. The numerous tunnels reduce the inside of the fruit to a brownish, pulpy mass and render it unmarketable. Winter fruits in which eggs are laid late in the season may seem normal at picking time and later rot suddenly as a result of the work of the maggots after the fruit has begun to soften in common storage.

When full-grown the maggot is about ¼ inch long and is whitish or yellowish white in color. It emerges from the fallen fruit and burrows into the soil to the depth of one or two inches. Here it molts, but it remains inside the old skin, which then becomes a tough, brownish, protective case, known as the *puparium* and resembling a plump grain of

wheat. Under exceptional conditions a few of the larvae may change to flies in the same year, but the greater number remain as pupae until the following summer.

Control

The most practical and effective method of control consists in spraying with lead arsenate, 2½ pounds in 100 gallons of the spray mixture, to kill the flies before they can lay their eggs. This spray is usually applied in combination with a fungicide for the control of apple scab. The addition of molasses or other sweetening is unnecessary and reduces the sticking qualities of the spray.

Recent experiments indicate that calcium arsenate may be substituted for lead arsenate (pages 7–8).

The first spray should be applied when the flies begin to emerge. In the Hudson Valley this is usually the last week in June. The flies tend to appear a few days later in western New York and in the Champlain area than in the Hudson Valley. For the more nearly accurate timing of apple-maggot sprays, large trap cages are used by the farm-bureau spray information service in certain counties to determine the daily emergence of flies from the ground. A second spray should be applied in about two weeks. These two sprays afford protection, not only against the apple maggot, but against the codling moth and apple scab as well. In cases in which a third apple-maggot spray is considered necessary, this should be applied early in August, when it will serve also as protection against the second brood of codling moth.

It will often simplify the spraying program to cut down, or top-work, the occasional sweet-apple trees in commercial orchards, since these are seldom profitable and often constitute a real menace because of the apple maggots that they harbor. Neglected trees in hedgerows, in adjoining fields, and about farm buildings also are such a menace, and should likewise be cut down or top-worked.

It is important that all trees in infested orchards be thoroughly sprayed. This applies not only to apple trees in their off-bearing year, but also to other fruits interplanted with apples. Experience has shown that failures to control the apple maggot are especially likely to result if spraying is confined to trees with fruit. Neglected orchards, and scattered trees near and adjoining commercial plantings, also should receive the maggot sprays.

Picking up and disposing of the dropped fruits in infested orchards is a worth-while practice supplementary to spraying.

Arsenical dusts are effective against the flies, but additional applications will be required if rains occur. Growers estimate that usually three dusts are necessary to give protection equal to that from two sprays.

LEAF HOPPERS

Leaf hoppers occasionally are troublesome pests of the apple in New York. These are small, whitish or greenish, active, sucking insects, found throughout the summer feeding on the underside of apple leaves. The various species of leaf hoppers are difficult to distinguish, and, as a result, there has been considerable confusion among experimental workers as to what

forms are important on the apple. To add to the confusion, some of the species have no common names and the scientific names of some have recently been changed.

The potato leaf-hopper, *Empoasca fabae* Harris (or *E. mali* Le Baron), formerly known as the *apple leaf-hopper,* has long been known as a pest of apple nursery stock. This green leaf-hopper attacks the tender growing shoots and causes a peculiar puckering and curling of the leaves. The most serious damage is to nursery stock and newly planted trees. This species is relatively unimportant as a pest in bearing orchards.

The white leaf-hopper (*Typhlocyba pomaria* McAtee) is the most troublesome species attacking bearing apple trees in New York. The insect passes the winter in the egg stage on apple. The overwintering eggs are deposited in the bark, and hatch during the latter part of May. There are two generations, the second reaching maturity in September. The white leaf-hopper feeds on the underside of the leaves, causing a whitish stippling on the upper surface. In severe cases the spots coalesce, the leaves become blanched, and little green coloring matter is left. In addition to injuring the leaves, the second brood of hoppers may speckle the fruit with excrement, rendering it unsightly and lowering its market value. This is true especially of Rhode Island Greening and other light-colored varieties.

Control

Leaf-hopper nymphs are readily killed by spraying with nicotine sulfate, either with soap or in combination with the regular sprays. Care must be taken to hit the underside of the leaves, where the insects are to be found. The time of hatching varies considerably in different parts of the State. In western New York, during some seasons the majority of the nymphs may be killed by a late pink spray, but, as the hatch is completed before the drop of the blossom, the calyx application is preferable. In the Hudson Valley, for the past two years hatching has not been complete until about ten days after the calyx application. It is an open question whether it will pay to spray for the first brood. If it is considered profitable to spray for this brood, the application should be made after the hatching is complete. In some seasons the calyx application coincides with the completion of the hatching of the first brood, and the addition of nicotine in this spray will effectively reduce the number of nymphs if the spraying is done thoroughly. The nymphs of the second brood usually appear in August, after the completion of the regular spraying schedule. If the nymphs are present in alarming numbers, they may be killed by spraying with nicotine sulfate, ½ pint in 100 gallons of water in which 5 pounds of fish-oil soap has been dissolved. If the weather is cool it is better to use ¾ pint of nicotine. This application should be made before the nymphs reach maturity.

BROOKS FRUIT-SPOT

(Caused by the fungus *Mycosphaerella pomi* Passerini)

Brooks fruit-spot, known also as *Phoma fruit-spot,* is a disease of apples frequently found in the Hudson Valley, where it has caused considerable

loss in some years. It has occasionally been found in western New York, but not to a serious extent.

Jonathan, Baldwin, Tolman Sweet, Grimes Golden, Rome Beauty, and Stayman Winesap are the varieties most commonly affected. In New York the disease has been found also on Rhode Island Greening, Bellflower, Ben Davis, Delicious, and Mann. Recently, Orange quinces have been found severely injured by this disease.

The spots, which seldom exceed 3/16 inch in diameter, are red or black when they occur on red areas of the fruit, and dark green or green on yellow surfaces. The center is usually flecked with black. The spots are irregular in outline, are slightly sunken, and usually are more abundant near the calyx end of the apple. They are often very inconspicuous at picking time, but if the fruit is not placed at once in cold storage they usually become more sunken and considerably larger, with a corky layer under the skin.

The Brooks fruit-spot, which is a fungous disease controlled by spraying, is often confused with stippen. Stippen is a fruit spot on apples caused by sudden changes in the water supply of the tree, and consequently it cannot be controlled by spraying. The sunken spots caused by stippen are very similar to those caused by the Mycosphaerella fungus in the early stages. However, at picking time the Brooks spots show black specks which are not present in stippen. At this time the spots caused by stippen usually turn brown, are more sunken, and have a distinct dry spongy area underneath which is not present under a Brooks spot. An apple affected with stippen will usually be found to contain brown streaks or spots of dry, spongy flesh throughout its pulp; such streaks or spots are not present with Mycosphaerella fruit-spot.

Control

Under New York conditions, where the regular summer sprays of lime-sulfur and lead arsenate are applied this disease is adequately controlled.

SOOTY BLOTCH AND FLY-SPECK

(*Gloedes pomigena* (Schweinitz) Colby)

(*Leptothyrium pomi* (Montagne & Fries) Saccardo)

Sooty blotch and fly-speck, although caused by two different fungi, are here considered under one heading because they frequently occur together and are controlled by identical measures.

Sooty blotch (figure 14) appears on the fruit as sooty brown or black spots or blotches, which may measure only ¼ inch in diameter or which may coalesce and cover the entire apple. Dealers often call this condition "cloud" or "cloudy fruit." The spots show a radiating structure composed of a thin felt of the dark, interwoven threads of the fungus.

Fly-speck, as the name indicates, consists of groups of black, shiny dots on the apple, closely resembling those made by flies (figure 14).

Sooty blotch and fly-speck are diseases of considerable economic importance in New York. Although the disfiguration caused by the fungi is superficial, it often reduces the grade and the market value of the fruit.

Control

These diseases usually are easily controlled where the customary summer applications are made for the control of codling moth and apple scab (page 7).

FIGURE 14. SOOTY BLOTCH AND FLY-SPECK ON APPLE FRUIT

BITTER ROT

(Caused by the fungus *Glomerella cingulata* (Stoneman) Spaulding & Von Schrenk)

Bitter rot is one of the most destructive apple diseases in the United States. New York is largely north of the area where this disease is serious. However, the disease has caused severe loss in a few orchards of the lower Hudson Valley, and is found occasionally, to a small extent, in western New York.

The spot appears on affected fruit, in July or August, as a small, faint, light brown discoloration beneath the skin. This spot soon enlarges and becomes darker brown, and when it is ½ inch in diameter small black dots appear beneath the skin of the sunken area. Later the dots increase in size and break through, exposing pink masses of spores close behind the advancing margin of the spot. Diseased fruits may fall or may remain on the tree over winter, but they rarely rot as they do in black rot. Cankers develop on the limbs also, and these are usually sunken and have a roughened surface and ragged edges.

The fungus overwinters in the cankers and in the mummied fruits on the tree. These cankers and mummied fruits produce summer spores, which are washed by rains to the fruit, where they germinate and grow

into the apple, causing the fruit spots. The spores are washed also into wounds in the branches, where new cankers form.

If bitter rot becomes established in an orchard, a special summer application of 3–5–50 bordeaux mixture may be required. The experience of growers has been that if this spray is applied, together with the practice of pruning out the cankers, the disease may be eradicated in a year or two under New York conditions.

TWO LATE-SUMMER CATERPILLARS

Yellow-Necked Apple Caterpillar (*Datana ministra* Drury)

Red-Humped Apple Caterpillar (*Schizura concinna* Smith & Abbott)

The yellow-necked and the red-humped apple caterpillar, each well described by its common name, often attract attention in August. They feed in colonies, and strip the leaves from occasional branches. They are most abundant on young trees that have not been sprayed. The injury caused by these caterpillars is not so serious as appearances would indicate. They work late in the season, after the foliage has reached maturity, but trees badly defoliated are more subject to winter injury.

Control

On bearing trees that are regularly sprayed, these caterpillars are of little importance. On young trees they may be jarred to the ground and crushed, or the trees may be sprayed with a poison while the caterpillars are small.

PEAR

A practical spray schedule for pears in New York must be built around the control measures required for pear psylla, since this pest is by far the most serious of any to the pear crop.

SPRAY OUTLINE FOR PEARS

Two methods of control are used against psylla. One is based on a cluster-bud application of lime-sulfur 1–8, the other on a dormant application of lubricating-oil emulsion or miscible oil.

When lime-sulfur is used for psylla

Cluster-bud spray (When the blossom buds have separated in the cluster, for Bartlett; when they begin to separate, for Kieffer)

Lime-sulfur	11 gallons
Water to make	100 gallons

The cluster-bud spray is directed against the eggs of the psylla. It will also kill scale and will prevent early infections of pear scab.

In orchards where scab has been serious, an additional application of a fungicide just as the buds show green tips may be advisable.

For effective results, it is absolutely essential to cover the underside of the branches from below.

First nymph spray (About a week after the petals have fallen)

Copper sulfate	2 pounds
Lime	30 to 40 pounds
Lead arsenate	3 pounds
Nicotine sulfate	1 pint
Water to make	100 gallons

This first nymph spray is sometimes called the calyx spray, but it is more effective if delayed until all the psylla eggs have hatched. This is normally about a week after the petals have fallen, but occasionally it may occur two weeks later. The tendency with most growers is to make this application too early and thus allow numerous nymphs to hatch after the spray has been applied.

In addition to killing the young psylla nymphs, this spray is effective against codling moth, false tarnished plant-bug, and scab.

If dust is used for psylla control, a 2-per-cent-nicotine lime mixture is indicated. This is effective only if delayed until the majority of the psyllas are in the later nymph and adult stages. For the control of scab and codling moth, 90–10 sulfur–lead-arsenate dust is indicated.

Summer sprays (When psylla becomes threatening)

The same materials are used in the summer sprays as are indicated for the first nymph spray except that lead arsenate is omitted. Applications made shortly before harvest should contain 1 pint of nicotine and from 3 to 5 pounds of soap for each 100 gallons of the spray mixture, to avoid residue on the fruit.

If dust is used for psylla control, a 2-per-cent-nicotine lime mixture is indicated. For the control of diseases and chewing insects, a 90–10 sulfur–lead-arsenate dust is indicated.

When an oil spray is used for psylla

Dormant spray (Early in the spring, when the flies appear on twigs and are ready to lay eggs)

Lubricating-oil emulsion or miscible oil diluted to contain 3 per cent of oil.

This dormant spray is effective against psylla and scale.

Pre-blossom spray (When the blossom buds begin to separate in the cluster)

Lime-sulfur	2½ gallons
Water to make	100 gallons

or

2–20–100 bordeaux mixture

This pre-blossom spray is made in order to prevent scab infection, and needs to be applied only in orchards where scab is likely to be present. In certain of these orchards where scab has been serious, two pre-blossom sprays may be advisable; the first should be applied just as the buds show green tips, and the second as the blossom buds begin to separate in the cluster.

Calyx spray (Soon after the petals have fallen)

Copper sulfate	2 pounds
Lead arsenate	·3 pounds
Hydrated lime	30 to 40 pounds
Water to make	100 gallons

The calyx spray is effective against codling moth and scab.

If the false tarnished plant-bug is present, or if psylla has not been controlled by the oil spray, 1 pint of nicotine should be added to the above formula, but for psylla the application should be delayed until all the eggs have hatched.

Summer sprays (When psylla becomes threatening)

Follow the directions given above for the lime-sulfur schedule.

PEAR PSYLLA

(*Psyllia pyricola* Förster)

The pear psylla is by far the most important insect pest of the pear in New York. It is most serious in the commercial pear-growing districts, and in some of these it has been so destructive and so difficult to control as to render commercial pear-growing largely unprofitable. The insect is not equally serious in all orchards, but is more of a problem in large plantings and in sheltered orchards. In seasons when the psylla is especially abundant, it is a serious problem in practically all orchards. Where it is not controlled, it often causes early defoliation and loss of crop, and so weakens the trees that they suffer winterkilling and a reduction in the succeeding year's crop.

The adults pass the winter under flakes of bark on pear and other near-by trees, and in trash and other shelter along adjacent fences and hedgerows. The psylla adults are commonly known as *flies* and have been aptly likened to tiny cicadas. They are about 1/10 inch long, are dark reddish brown, and have relatively large, transparent wings which slope roof-like over the abdomen. Their legs are adapted for jumping.

The flies emerge from their hibernating quarters during sunny days in early spring when the temperature is about 50° F. If the weather continues warm, they crawl out on the smaller branches and spurs of the trees, and in a few days the females begin to lay eggs. Later, intermittent cold spells may cause the adults to return to shelter and thus interrupt and prolong the egg-laying period. In normal seasons most of the eggs have been deposited by the time the blossom buds separate in the cluster, but in cool seasons egg-laying may continue through the blossoming period. The small, elongate eggs are laid end to end in crevices around the buds, mainly on the underside of the smaller branches and fruit spurs and later on the lower surface of the opening leaves along the midrib. Although they are white when laid, the eggs soon change to lemon yellow, deepening to orange as they near hatching. The eggs hatch in nine days to four weeks, depending on the temperature. The majority of the eggs hatch during the blossoming period, and in normal seasons hatching is practically completed about a week after the petals have fallen although in some years the last eggs are not hatched until two weeks after petal-fall.

The newly hatched nymphs are so small as to be hardly visible to the unaided eye. They migrate to the opening buds and settle at the bases of the leaf petioles and the fruit stems, where they pierce the tissue with their bristle-like mouth-parts and suck out the plant juices. They grow rapidly, passing through five immature stages and becoming winged adults at the fifth molt. During the first three stages, the nymphs are yellow and are covered by a sticky excretion called *honeydew*. The fourth and fifth stages are known as *hardshells*, and during these stages relatively little honeydew is secreted. In the fourth stage the body is marked with blue shading to brown, and in the fifth with dark brown. The summer flies are smaller, and lighter in color, than the overwintering adults.

The completion of the life cycle requires about a month, and there are three or four generations in a season. Each female lays about 500 eggs. Under favorable conditions the insect may increase to enormous numbers, even from a few overwintered flies. The summer broods overlap to a considerable extent, so that after the first generation all stages may be present at the same time.

The feeding of the nymphs dwarfs the leaves, produces brown, dead areas, and in severe instances causes the foliage to drop prematurely. Foliage injury results in undersized, poor-quality fruit, prevents normal fruit-bud formation, and weakens the tree. Early defoliation is often followed by winterkilling of branches and by a reduction in the crop for several succeeding years. The fruit is often badly stained and reduced in market value by a sooty fungus which grows in the sticky coating of honeydew excreted in large quantities by the nymphs.

Control

The pear psylla is a very difficult pest to control and no single treatment can be relied upon when it is abundant. One system that has been generally and successfully employed under New York conditions consists of: (1) an application, known as the cluster-bud spray, of lime-sulfur 1–8, just before blossoming, to kill the eggs laid by the overwintered flies; (2) an application of a nicotine spray shortly after petal-fall, to kill the newly hatched nymphs of the first generation; and (3) applications later of nicotine sprays if psylla becomes abundant during the summer. In average years, thorough and well-timed cluster-bud and first nymph sprays usually give commercial control for the season.

The cluster-bud spray, if applied thoroughly and at the proper time, is very effective in normal years, since the great majority of eggs have been deposited and have developed to the stage where they are readily susceptible to lime-sulfur 1–8. In cool seasons the spray is somewhat less effective, because many eggs will have been laid at so late a date that they will not have reached the susceptible stage by the time the lime-sulfur spray is applied. Furthermore, a considerable number of eggs may be deposited after the latest date at which the spray can be safely applied. But even under these conditions the cluster-bud spray is worth while whenever psylla is a serious problem, since it prevents considerable injury that would otherwise occur before the first nymph spray. It also makes the nymph sprays more completely effective by killing early-laid eggs and early-hatched nymphs. As a result, most of the psyllas left on the tree are in the more susceptible early-nymph stages when the nymph spray is

applied. To be most effective, the cluster-bud spray should be applied at as late a date as possible before blossoming.

Slight foliage injury is likely to result from the use of lime-sulfur 1–8 at the cluster-bud stage, but there is practically no danger of injuring the flower buds. The Bartlett variety has but little leaf area exposed just before blossoming, while in the Kieffer variety the leaves are much more expanded. To avoid danger of burning, it is well to spray Kieffer just as the buds begin to separate in the cluster. Seckel and Clapp can be safely treated a little later; Bartlett, Bosc, and other varieties should be sprayed when the buds are fully separated, the operation being completed just before blossoming. If overwintered flies are still numerous and still laying eggs, it may sometimes pay to add 1 pint of nicotine to each 100 gallons of the spray mixture.

Only a very thorough application is worth while, and careless spraying is certain to result in failure. A majority of the psylla eggs are deposited on the underside of the spurs and the smaller branches and on the water sprouts, so that the most effective method is spraying from the ground.

The first nymph spray is especially necessary where no cluster-bud spray is applied, and is also advisable as a supplementary application to kill the nymphs that have hatched from eggs missed in the earlier spray or laid after the spray was applied. At this time psyllas are relatively few in numbers and are mostly in the susceptible nymph stages. The species increases very rapidly, and later sprays are less effective owing to the overlapping of broods and the presence of eggs, which are not susceptible to nicotine.

The first nymph spray should be applied when practically all of the eggs laid by the overwintered flies have hatched but before a large number of early-hatched nymphs have reached the adult stage. This usually occurs about a week after the petals have fallen, but the time depends entirely on the seasonal development of the psylla and can be accurately determined only by close observation of psylla development. The following spray mixture is used:

Copper sulfate	2 pounds
Hydrated lime	30 to 40 pounds
Lead arsenate	3 pounds
Nicotine sulfate	1 pint
Water to make	100 gallons

A driving spray with considerable pressure should be employed, so that the spray will be forced between the bases of the leaf petioles and the fruit stems, where many of the nymphs are sheltered. Thorough spraying is essential.

In seasons of abundance, or where the early sprays are omitted or carelessly applied, a later application may be necessary. When considerable amounts of honeydew indicate that psylla is abundant, a spray should be applied in July at the time when most of the second brood are in the early-nymph stages.

Sometimes psylla becomes abundant in early August, shortly before fruit-picking, and threatens to smut the crop. When this occurs, a combination of 3 to 5 pounds of soap and 1 pint of nicotine sulfate to 100 gallons of water should be used instead of the lime-and-nicotine mixture,

to avoid residue on the fruit. This mixture is very effective and can be applied safely until within a few days of picking. Resin fish-oil soap has the advantage over other soaps of not curdling in hard water.

Another schedule which is followed with considerable success by many growers, and which is somewhat less expensive, consists of the application of a dormant oil spray when the flies appear in early spring. This is followed when necessary by summer nymph sprays, as in the other schedule. Lubricating-oil emulsion or miscible oil is used, diluted so as to contain 3 per cent of oil when applied. The lubricating-oil-emulsion spray can be prepared from commercial stock emulsions, or from Diamond Paraffin lubricating oil, or oils having similar specifications, emulsified in a spray tank. The spray should be applied on sunny days in March or early April when the flies appear in numbers on the branches but before many eggs are laid.

Although the killing of flies is important, much of the effectiveness of the spray results from the coating of oil residue left on the tree. This repels the flies so that fewer eggs are deposited, and also kills many of the newly hatched nymphs as they attempt to crawl over it to the leaves.

When psylla becomes abundant during the summer, nymph sprays are applied as in the other schedule (page 45).

A single application seldom injures the trees unless they are exceedingly weak. However, if repeated applications are made annually, oil injury may result on those with moderate to low vitality. This is most noticeable in the case of trees weakened by winter injury or by previous attacks of the pear psylla. On moderately weak trees the oil treatment should not be continued for more than one or two years in succession. If the trees are vigorous the orchard should be carefully watched, and when oil injury is observed the treatment should be discontinued. If the trees are extremely weak it is not safe to use oil sprays.

FALSE TARNISHED PLANT-BUG

(*Lygus communis* Knight)

The false tarnished plant-bug is present in occasional pear orchards throughout the State, and may cause a large proportion of the fruit to become knotty and deformed.

The insect passes the winter in the egg stage in the bark of the smaller branches of the trees. The eggs hatch during the blossoming period, and the young nymphs, after feeding for a time on the expanding leaves, attack the fruit as soon as it has set. In feeding, they puncture the fruit with the bristles of the beak and suck out the plant juices. The tissue around the puncture becomes hard and gritty. Growth at that point is retarded, and a deep pit or dimple develops. Badly punctured fruits are not only deformed but also dwarfed. The nymphs are at first pale in color, but they become greenish after the first molt. They pass through five immature stages and become mature about the middle of June. The adult is about ¼ inch in length and is light brown. There is only one brood a year. Most of the injury is caused during June, while the fruits are still small.

Control

The nymphs can be killed by a thorough application, made soon after the petals have fallen, of nicotine sulfate, 1 pint in 100 gallons of water in

which 3 to 5 pounds of soap has been dissolved. The first psylla-nymph spray, containing nicotine sulfate, copper sulfate, and hydrated lime (page 45), also is effective, and, if this is used, no extra application is necessary.

PEAR SCAB

(Caused by the fungus *Venturia pyrina* Aderhold)

Pear scab is very similar in appearance to apple scab and is caused by a closely related fungus, but the two diseases are distinct. The pear-scab fungus does not attack apple, nor does the apple-scab fungus attack pear.

The pear-scab fungus, like the apple-scab fungus, overwinters as partly developed fruiting bodies (perithecia) in the old fallen scabby leaves. Unlike apple scab under New York conditions, it overwinters also to a considerable extent in affected twigs.

The spring spores (ascospores) of the pear-scab fungus mature in the perithecia somewhat later than do those of the apple-scab fungus, and are readily recognized under the microscope by their greater length. When the ascospores are ripe they are shot out of the dead leaves during wet periods, and infections take place as described for the scab on apple. Summer spores also are produced on the affected twigs and are washed to leaves and fruit, creating an important method of spread which very rarely exists with apple scab in New York.

In general, pear scab is not serious except on such varieties as Flemish Beauty, Winter Nelis, and Easter Beurre. In certain areas of western New York, scab has become serious on commercial varieties such as Seckel, Bartlett, and Bosc.

Control

In most commercial pear orchards, the seasonal spray schedule followed for pear psylla and other troubles is sufficient for scab control. An application of a fungicide at the cluster-bud stage is advisable, and in 1933, in the areas where scab had been serious, a special application of a fungicide as the buds were first showing green tips was found to be of great value.

CODLING MOTH

(*Carpocapsa pomonella* Linnaeus)

(See also under *Apple*, page 30)

The codling moth is an important pest of the pear and sometimes it causes serious injury where control measures are not used. Because of the tougher character of the pear skin, a larger proportion of the larvae are thought to enter through the calyx cup than in the case of the apple.

Control

The first spray for the control of codling moth is applied shortly after the petals have fallen, and contains 3 pounds of lead arsenate for each 100 gallons of the spray mixture. The arsenical is usually added to the first nymph spray (page 45). If psylla is not a pest in the orchard, the arsenical should be used with a bordeaux mixture containing 2 pounds of copper sulfate, 20 pounds of hydrated lime, and water to make 100 gallons. If

additional sprays are applied, it may be necessary to wash the fruit to remove residue. Because of the difficulty experienced in washing Kieffer pears, residue should be avoided as far as possible on that variety.

QUINCE CURCULIO

(*Conotrachelus crataegi* Walsh)

In a few scattered orchards throughout the State, the quince curculio sometimes causes considerable injury to pears. Fruit injured by the feeding and egg-laying punctures of the curculio frequently becomes knotty and deformed, but the presence of feeding punctures, even without deformation, will cause the pears to drop just before picking time. In some orchards, from 70 to 80 per cent of the crop has been lost because of attack by this pest.

Control

Infested orchards should be sprayed with 2½ pounds of lead arsenate and 20 pounds of hydrated lime in 100 gallons of spray mixture as soon as the beetles emerge from the ground. The time of emergence may vary considerably from year to year, but in the Hudson Valley it is usually during the first week in June while in western New York it is sometime between June 15 and July 15. The time of appearance of the beetles can be determined by jarring trees at intervals, beginning in late May. An easy method of determining the time of application is to watch for the first feeding punctures on the fruit. These usually will be found first near the stem end of the pears. During some seasons a second application is advisable. The fruit should be well covered with lead arsenate from the first appearance of the beetle until about August 1. If these late applications are made, it will probably be necessary to wash the fruit to remove residue.

PEAR MIDGE

(*Contarinia pyrivora* Riley)

The pear midge is now a major pest of the pear in the Hudson Valley, and it also causes serious injury in some orchards in Genesee and Ontario Counties. In badly infested orchards the entire crop of certain varieties may be destroyed. All varieties are attacked, but Lawrence is the most seriously injured and Kieffer the least.

The adult pear midge is a small, mosquito-like fly, distinguishable from other midges by its more delicate build and its unusually long legs. The midges usually emerge from the ground at about the time the blossom buds of Clapp Favorite are separating in the cluster. The female soon moves to the buds, and, by means of her long, flexible ovipositor, lays her eggs inside the unopened blossoms. This is done as soon as the petals have developed sufficiently to permit the insertion of the ovipositor. From 20 to 30 eggs may be deposited in a single bud. The eggs hatch in about a week, and the tiny larvae work their way into the ovary and hollow out a large cavity in the center of the developing fruit.

Infested fruits are at first larger than normal, but later they become stunted and deformed and in a few weeks drop to the ground. When the larvae are full-grown, they either drop to the ground through cracks which

develop in the side of the fruit or drop with the fruit. They usually pupate soon after entering the soil, and remain in this state until the following spring.

Control

The pear midge can be controlled by a contact spray to kill the adult midges before they can lay their eggs. The spray should be applied when the individual blossom buds have all separated from one another in the cluster. The application must be completed without delay, since the time for effective spraying is often only a day or two. Owing to the difficulty of proper timing of the spray, growers should avail themselves of the farm-bureau spray information service. The entire tree, including the trunk, should be thoroughly covered, and all the trees in the orchard should be sprayed. Nicotine sulfate, 1 pint in 100 gallons of the spray mixture, is added to a solution of lime-sulfur 1–8 if psylla is to be combated at the same time, or to lime-sulfur 1–40 or bordeaux mixture if for pear midge alone.

PEAR THRIPS

(*Taeniothrips inconsequens* Uzel)

Although pear thrips is present throughout the State, it has been destructive chiefly in parts of the Hudson Valley. Occasionally an orchard in western New York is severely attacked. In the Hudson Valley, during some seasons the insect causes severe blasting of blossoms and leaf buds and a heavy reduction of the crop in a considerable number of orchards. The thrips attacks plum, cherry, and apple, also, but the injury to these fruits is negligible.

The adult thrips are slender, brownish insects about 1/20 inch in length, with long, narrow wings fringed with long hairs. In the spring they emerge from the soil and appear on the trees, usually just as the buds are bursting. They soon work their way into the opening buds and attack the tender flower and leaf parts. If the thrips are numerous, and especially if cool weather retards the further opening of the buds, many blossom clusters are shriveled or blasted and later fall off, while others are stunted and deformed and drop their fruit prematurely. The thrips lay their eggs mainly in the stems of the blossoms and leaves, beginning as soon as the buds open. The young thrips are small, white creatures, with red eyes, and they hatch in numbers during the blossoming period. They feed in the calyx cups of the blossoms and on the foliage, thus adding to the injury caused by the adults. They become full-grown in two or three weeks, fall to the ground, and enter the soil, sometimes to a considerable depth. In the fall they change to pupae. The pupae pass the winter in tiny cells in the ground.

Control

The only known method of control for pear thrips consists of spraying with 1 pint of nicotine sulfate in 100 gallons of either a miscible oil diluted at manufacturers' recommendations or a 3-per-cent lubricating-oil emulsion. This spray will kill the adult thrips while they are clustered on the opening buds. The time for effective spraying is short, and the grower should watch his orchard carefully and should spray as soon as thrips are found to be numerous on the buds and the branches. If thrips continue

to appear, a second application a few days later may be desirable. In seasons when large numbers of thrips swarm on the buds before these are expanded enough for the insects to enter, the thrips can be successfully controlled. When, however, they emerge a few at a time and the buds are open enough for them to enter, satisfactory control is impossible. This application controls pear psylla as well as pear thrips.

A good spray containing nicotine, if thoroughly applied shortly after the petals have fallen, will kill a large proportion of the young larvae, or "white thrips," and will greatly reduce the infestation for the following year. This application corresponds to the regular first psylla-nymph spray and contains the same materials. (See page 45.)

BLISTER-MITE

(*Eriophyes pyri* Pagenstecher)

The leaves of pear and of apple are often disfigured by small, reddish or greenish yellow blisters, caused by blister-mites. These later turn brown. Badly infested leaves turn somewhat yellow and fall prematurely. The adult blister-mites pass the winter in the buds beneath the second and third scales. With the bursting of the buds in the spring, the mites migrate to the leaves, burrow through the upper surface, and lay eggs. The young mites feed on the tender tissue inside the leaf, and cause the formation of swellings or blisters. When mature, the mites escape from the blisters through minute holes in the underside of the leaf. They then migrate to fresh leaves and start new blisters. Breeding is continued throughout the summer.

Control

This pest is seldom serious enough to warrant special control measures. It is readily controlled by lime-sulfur 1–15, or by miscible- or lubricating-oil sprays applied in the fall after the wood has hardened or in the spring before the buds break. The oil sprays used for psylla and thrips will control this pest also.

PEAR LEAF-BLIGHT

(Caused by the fungus *Fabraea maculata* (Leville) Atkinson)

Pear leaf-blight is caused by the same fungus that produces leaf-blight on quince. The life history of the fungus is described on page 71.

Leaf-blight occurs commonly on pears in practically all nursery districts. It is said to be more abundant in the Hudson Valley pear orchards than elsewhere in New York. The greatest damage is on pear seedlings in the nurseries, but occasionally severe injury is done to leaves and fruit of trees in bearing orchards.

The leaf-blight fungus causes a spotting of pear leaves very similar to that produced on quince by the same fungus. The spots on the leaves differ from the spots of the Mycosphaerella leaf-spot by being smaller, more nearly circular, and darker-colored. There is one raised black dot in the center of the leaf-blight spot, in contrast to the numerous small black bodies in the Mycosphaerella leaf-spot. The spots on the fruit are at first red, but later they become dark-colored. The skin is roughened, and cracking of the fruit may follow.

Control

The disease may be controlled with lime-sulfur or bordeaux mixture. Unfortunately, lime-sulfur, even at a dilution of 1–50, is extremely unsafe on pear trees after the blossoming period. Bordeaux mixture 3–8–50 will control the disease but is likely to cause russeting of the fruit. Experiments have not been made to determine the control obtained by the weak bordeaux spray recommended for pears in the spray schedule containing but 2 pounds of copper sulfate in 100 gallons of the spray mixture (page 45). Unless the leaf-blight has been serious in the orchard, it would seem safer to use this weak copper-lime spray on bearing trees. On seedlings in nurseries the stronger bordeaux mixture may safely be used. Sulfur dust, copper-lime dust, and dry-mix sulfur-lime spray have not been tested, but from the results obtained with the disease on quinces it would seem probable that the sulfur dust and the dry-mix sulfur-lime spray might give commercial control, while the copper-lime dust cannot be relied upon.

MYCOSPHAERELLA LEAF-SPOT

(Caused by the fungus *Mycosphaerella sentina* (Fries) Schroeter)

Mycosphaerella leaf-spot is usually called *Septoria leaf-spot* or simply *pear leaf-spot.*

When heavy leaf infections occur, defoliation may take place by August or earlier. This results in checking the ripening of buds and shoots, and causes the tree to be susceptible to winter injury. The leaf-spot is recognized by the dark, angular spots with light gray centers, which contain the very dark, pin-point-like fruiting bodies of the fungus. The fungus overwinters in the fallen leaves, from which its spores are shot in the spring during rain periods.

Control

This disease is of little importance in well-sprayed pear orchards. Frequent inquiries regarding it are received from owners of unsprayed pear trees.

CHERRY

Under New York conditions, cherries are sprayed principally for the control of leaf-spot, fruit-flies, and brown rot. In some locations the plum curculio also may require attention. The black cherry aphis is confined as a pest mostly to sweet cherries.

SPRAY OUTLINE FOR SOUR CHERRIES

Pre-blossom (Just before the blossoms open)

Lime-sulfur	2½ gallons
Water to make	100 gallons

This spray is applied for the control of brown-rot blossom-blight. It is important in most seasons on English Morello, and usually is not necessary on other varieties of sour cherries.

If dust is used, dusting sulfur is indicated.

Petal-fall (When the last of the petals are falling)

Lime-sulfur	2½ gallons
Lead arsenate	2½ pounds
Water to make	100 gallons

This spray is effective against leaf-spot, brown rot, and curculio.

If a dusting schedule is followed, a 90–10 sulfur–lead-arsenate mixture is indicated. If curculio is abundant, an 80–20 mixture of the same materials may be used.

Shuck spray (When the shucks have fallen from the growing fruit)

Lime-sulfur	2½ gallons
Lead arsenate	2½ pounds
Water to make	100 gallons

This spray is effective against curculio, leaf-spot, and brown rot.

If dust is used, an 80–20 sulfur–lead-arsenate mixture is indicated.

First fruit-fly spray (A week after the fruit flies have first appeared, or about the time Early Richmond first shows a tinge of color)

For canning cherries that are to be washed.

Lime-sulfur	2½ gallons
Lead arsenate	2½ pounds
Water to make	100 gallons

To avoid lead residue, 2 pounds of calcium arsenate with 4 pounds of hydrated lime may be substituted for the 2½ pounds of lead arsenate in this formula.

Second fruit-fly spray (About ten days later than the first fruit-fly spray, or when Montmorency begins to color)

For canning cherries that are to be washed.

The same material is used as for the first fruit-fly spray.

If dust is used for fruit-fly control, a 90–10 sulfur–lead-arsenate mixture is indicated. The applications should be made at the same times as are indicated for sprays, but, if heavy rains occur, extra dusts should be applied following them.

After-picking spray (soon after harvest)

Lime-sulfur	2½ gallons
Water to make	100 gallons

This spray need be applied only in years when leaf-spot is present.

If a dust schedule is followed, an application of dusting sulfur is indicated.

SPRAY OUTLINE FOR SWEET CHERRIES

Dormant (Before the buds open)

Tar-distillate emulsion containing 1.8 per cent of creosote oil in the diluted mixture.

This spray is applied for the control of the black cherry aphis.

Pre-blossom (When the bud scales separate and expose the green blossom buds)

Nicotine sulfate	1 pint
Lime-sulfur	2 gallons
Water to make	100 gallons

If brown-rot blossom-blight is not likely to be present, 3 to 5 pounds of soap may be substituted for the lime-sulfur.

Later sprays

For all later applications the sour-cherry schedule should be followed, substituting 2 gallons for 2½ gallons of lime-sulfur in the 100 gallons of spray mixture.

If dust is used, the dust schedule for sour cherries should be followed.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

(See also under *Peach*, page 63)

The brown rot of stone fruits is particularly destructive to cherries in warm, wet seasons. Sweet cherries are more susceptible than are sour varieties. The life history of the fungus given on page 64 applies also when cherries are infected.

Brown-rot blossom-blight is more likely to be serious in sweet cherries, and in English Morello among the sour varieties. In 1924 the weather in western New York was favorable for infection at blossom time, and considerable blossom blight was found on Montmorency cherries in that season. As a result, the larger commercial fruit-growers have generally made a pre-blossom application on all varieties of cherries. No appreciable loss from blossom blight has occurred on Montmorency since 1924, however, and the spray information service has recommended a pre-blossom application for sweet cherries only, and in some cases for English Morello as well. The subsequent development of the fungus on cherry is similar to that described under *Peach* (page 64).

Control

Adequate control of brown rot is obtained in sour cherries by including the 2½ gallons of lime-sulfur in the regularly applied sprays for control of leaf-spot, curculio, and fruit-flies. In the case of English Morello, it will probably be advisable to start the schedule of sprays with the pre-blossom, while for the other sour cherries the petal-fall will normally be the first spray.

For sweet cherries, 2 gallons of lime-sulfur applied in the regular schedule, beginning with the pre-blossom spray, will give adequate control. Growers of sweet cherries sometimes find that an application of dusting sulfur about a week prior to picking will enable them to leave the crop on the trees longer, thus allowing the fruit to attain greater size without appreciable loss from brown rot. Some difficulty is encountered in obtaining pickers where this practice is followed, because of irritation to their eyes caused by the dust.

BLACK CHERRY APHIS

(*Myzus cerasi* Fabricius)

The black cherry aphis frequently causes serious injury to sweet cherries in New York but is seldom serious on sour cherries. This pest passes the winter in the form of shining black eggs on the smaller branches near the buds. These eggs hatch as the buds are opening in the spring. The aphids reproduce so rapidly that within a few weeks they may curl the leaves of the terminal shoots and the fruit clusters. The injured leaves turn brown and die, and the fruit is dwarfed. The aphids also excrete large amounts of honeydew, which collects on the leaves and the fruit. A sooty fungus grows in the honeydew, making the fruit practically unmarketable.

Control

Effective control of the black cherry aphis has been obtained by spraying with tar-distillate emulsion containing 1.8 per cent of creosote oil in the diluted mixture. (See table 2, page 83.) The spray should be applied in the spring while the buds are still brown and do not show any green. If this treatment has been omitted, the only alternative is to spray with nicotine sulfate.

CHERRY FRUIT-FLIES

Cherry fruit-flies are present in all the orchards of the State and cause most of the familiar wormy cherries. They are bright-colored flies, somewhat smaller than the house fly and distinguished by prominent dusky bands or markings on the wings. There are two species of these flies: the dark-bodied fruit-fly, *Rhagoletis fausta* Osten Sacken; and the white-banded fruit-fly, *Rhagoletis cingulata* Loew. The abdomen of the dark-bodied fruit-fly is entirely black, while that of the white-banded fruit-fly is marked by a series of distinct white crossbands (figures 15 and 16).

Figure 15. The dark-bodied cherry fruit-fly (Rhagoletis fausta)

Figure 16. The white-banded cherry fruit-fly (Rhagoletis cingulata)

There is also a difference in the pattern of the wing markings of the two species. Both species are present in most orchards, but the white-banded fly is usually by far the more abundant.

The cherry fruit-flies spend about ten months of the year in the soil beneath the trees, in a puparium resembling a grain of wheat. They then change to the fly stage, emerge from the ground, and appear on the trees. In central and western New York, emergence begins about June 1 and

continues for a month or longer. The dark-bodied flies begin to appear a week or ten days earlier than do the white-banded flies.

On the trees the flies move actively about over the foliage and the fruit, and suck up drops of moisture, gums, juices, or almost any material present. Particles of solid material are dissolved by means of saliva secreted through the mouth-parts.

The female deposits her small, whitish eggs singly in the flesh of the fruit, through small punctures which she makes in the skin with her sharp ovipositor. The eggs hatch into tiny, whitish, legless maggots, which burrow at first around the pit but later through the flesh. The outside of infested fruit usually appears perfectly normal until the maggot is nearly full-grown, when sunken spots appear. When full-grown the maggot eats its way out of the fruit, falls to the ground, and enters the resting stage in the soil.

Control

For many years, lead arsenate at the rate of 2½ pounds in 100 gallons of the spray mixture has given excellent control under commercial conditions. Canning cherries are thoroughly washed before processing, and spray residues are effectively removed, thus permitting the use of a full schedule for fruit-fly control. Growers may wish to modify the schedule if the fruit is to be consumed fresh. In this case it is suggested that the lead arsenate be reduced to 1½ pounds in the second application, or calcium arsenate may be substituted. The best method of timing the sprays is by the use of trap cages to determine just when the flies emerge, supplemented by frequent examination of the trees, beginning about June 1, to determine whether flies are present. This information is available to growers in counties where the farm bureau conducts a spray information service. The first spray should be applied about one week after the beginning of emergence, and should be followed by a second spray ten days to two weeks later. Since Morello cherries are picked later than are the other varieties, a third spray will be necessary on these to protect them until picking time. Morello cherries are susceptible to arsenical injury resulting in shriveling of fruit stems and fruit. Where thorough spraying is done and maggot control has been good in the past, the lead arsenate may be reduced to 1 pound in 100 gallons in the sprays for maggot.

Where information on the emergence of the flies is not available, a fairly satisfactory method of timing is to apply the first spray to all varieties when the Early Richmond cherries are just beginning to show color. Although usually the flies are present earlier, they do not deposit eggs in the fruit until it begins to color a little.

When spraying cherries for the control of fruit-flies, it is essential to spray also interplanted trees and adjoining trees or hedgerows, since otherwise the flies will harbor safely in these, and later will move to the cherries and lay eggs before being poisoned. The first four or five rows of adjoining orchards also should be sprayed. If interplanted with peaches, which cannot be safely sprayed, the cherries should be sprayed as soon as the first flies appear, in order to kill the flies before they can move to the peaches.

Where dusts are used instead of sprays, the covering should be renewed after every heavy rain during the danger period.

CHERRY LEAF-SPOT

(Caused by the fungi *Coccomyces hiemalis* Higgins and *C. lutescens* Higgins)

Cherry leaf-spot is the disease which, when uncontrolled, causes the greatest loss to the cherry industry in New York. In years very favorable to the development of the leaf-spot, such as 1922, 1924, and 1928, many orchards that were not properly sprayed were defoliated. Such defoliation weakens the trees and winterkilling is very likely to follow. Careful studies made in Michigan after the early defoliation of unsprayed trees in 1922 showed that the trees which had been prematurely defoliated produced fewer blossoms, the blossoms were poorly developed and slower in opening, fewer cherries ripened, and the cherries were smaller. Almost one-fifth of the fruit spurs died on the defoliated trees during the following winter. The spurs that lived produced only 42 per cent of the crop per spur which was obtained on the trees where leaf-spot was controlled. In addition to this immediate effect on the following year's crop, the defoliation reduced the spur development, thus lowering the production for a number of years.

On an affected leaf, dark blue spots, usually not more than $\frac{1}{8}$ inch in diameter, appear on the upper surface. These spots soon become dark red or reddish brown and extend through the leaf, and during rainy weather light pink-colored masses appear on the underside of the leaf in the center of the spots. The spots may occur on the fruit stems also (figure 17), causing the fruit to ripen unevenly. Spots on the fruit occur rarely and are not of economic importance.

Leaf-spot, a fungous disease, may be confused with a leaf-drop of cherry in which no disease organism is concerned. This physiological leaf-drop is apparently correlated with winter injury to the cherry trees. The name *yellow leaf* has been used to describe this trouble, but, unfortunately, *yellow leaf* has been extensively used also as a name for the fungous leaf-spot. The leaves of trees affected with this physiological leaf trouble turn yellow or a lighter shade of green, and drop in large numbers. In most cases this drop begins earlier than does the leaf-drop caused by the leaf-spot fungus. Both troubles may, and frequently do, affect the same tree. The fungous leaf-spot may be positively identified after wet weather by the masses of spores which appear in the center of the spots, usually on the under surface of the leaf. It is important that the grower should be able to identify the true fungous leaf-spot, since it is controlled by spraying while the physiological dropping of leaves is not.

The fungus that causes the leaf-spot has a life history much like that of the apple-scab fungus. The leaf-spot fungus overwinters on the fallen leaves, and its fruiting bodies usually mature during the blossoming period of the cherry. During rain periods the spores are shot out from the fallen leaves and are carried up by air currents. If these spores lodge on a leaf, and moisture and temperature conditions are favorable, the spore germinates and a leaf-spot results in one or two weeks. Masses of summer spores are produced during wet weather, usually on the under surface of the leaf. In later rain periods these are carried by rain and wind to healthy leaves, causing new spots which appear one or two weeks later. The disaese causes the cherry leaves to turn yellow and fall. Occasionally a leaf

FIGURE 17. CHERRY LEAF-SPOT ON LEAVES AND ON FRUIT STEMS

forms an abscission layer around a spot, causing it to drop out and producing a shot-hole effect. During long, warm rains the spread of the disease is very rapid.

Control

Turning-under the fallen leaves greatly reduces the number of spores shot by the fungus in the spring rains. It is not possible, however, to control the leaf-spot fungus by this means, since not all of the leaves are destroyed even by the most careful work. Dependence must be placed on a protective coating of a material which will prevent the spores from germinating and growing into the green tissue. Sulfur is used, in the form of lime-sulfur (2½ gallons in 100 gallons of the spray mixture), dry-mix sulfur-lime (16 pounds in 100 gallons of the spray mixture), or sulfur dust. Copper has been used in the form of bordeaux spray or copper-lime dust. All of these materials give adequate control, but the copper compounds have so frequently resulted in injury that they have been discarded.

The effect of weather conditions on the development of the cherry-leaf-spot fungus has not yet been thoroughly worked out. It seems that the ascospores, which are shot from the old fallen leaves, require a higher temperature during rain periods than do those of the apple scab, in order to germinate and enter the new leaves. Without more data than are available at present, it seems that the safest spray schedule to be followed is: an application when the petals fall; a second application when the shucks are off the young fruit; and two later applications timed primarily for control of the cherry maggot. In addition, in years when the leaf-spot is present in the orchard at picking time, a spray should be applied immediately after harvest.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 68)

The plum curculio is present in most cherry orchards and is especially troublesome near stone walls or other hibernating shelter. The larva of the plum curculio is rather thick-set, is curved, and has a distinct head.

The beetles usually begin to attack the fruit shortly after the petals have fallen, and lay most of their eggs during the following two weeks. Unlike most of the other fruits attacked by the curculio, infested cherries usually remain on the tree until picking time.

Control

Sprays containing 2½ pounds of lead arsenate are effective against the plum curculio. The first spray should be applied as soon as most of the petals have fallen. A second spray should be applied when the shucks have fallen from the growing fruits. Lime-sulfur is included in both applications, for control of leaf-spot and brown rot.

PEACH

Under New York conditions, the peach suffers severely from the attacks of three diseases— leaf curl, brown rot, and scab—and, in certain localities,

from the ravages of the plum curculio. The oriental fruit-moth is now well established in the State, and no method of control by spraying has been devised.

SPRAY OUTLINE FOR PEACHES

Leaf-curl spray (In late fall or early spring, before the buds swell)

Lime-sulfur	6½ gallons
Water to make	100 gallons

If San José scale is present, 11 gallons of lime-sulfur should be used.

Pre-blossom spray (When the blossoms show pink, or a little earlier if a rain period threatens)

Lime-sulfur	2 gallons
Water to make	100 gallons
or	
Dry-mix sulfur-lime	16 pounds
Water to make	100 gallons

This application is made to prevent brown-rot blossom-blight.
If a dust schedule is followed, an application of dusting sulfur is indicated.

Shuck spray (When the shucks are falling)

Dry-mix sulfur-lime	16 pounds
Extra hydrated lime	13 pounds
Lead arsenate	2 pounds
Water to make	100 gallons

This application is made to control brown rot, scab, and curculio.
If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated.

Summer sprays (The first, two or three weeks after the shucks have fallen; the second, two or four weeks before the fruit ripens)

Dry-mix sulfur-lime	16 pounds
Water to make	100 gallons

These sprays are applied for the control of brown rot and scab.
If a dust schedule is followed, an application of dusting sulfur is indicated.

PEACH LEAF-CURL

(Caused by the fungus *Exoascus deformans* (Berkley) Fuckel)

The leaf-curl of peach has long been known by commercial growers as a very injurious disease. In New York, the disease is most common and destructive in the western New York fruit belt along Lake Ontario. Even there it is not present to a serious extent every year, but in wet seasons it causes immense damage to unsprayed orchards.

The loss caused to peach-growers by leaf-curl results from the dropping of leaves in the spring. This loss of leaves lowers the vitality of the trees, may cause a partial or a total failure of the trees to set a crop of fruit, and causes the trees to be much more susceptible to winterkilling. Loss of leaves for several consecutive seasons will kill trees outright. Young nursery stock may be killed or made worthless as a result of leaf-curl.

The disease is first recognized by a reddening and an arching of the young leaves as they begin to appear. Later these leaves become thickened and curled or crinkled, and have a yellowish color and a silvery sheen. These diseased leaves die and drop off in June, and the tree replaces them with a new growth of healthy leaves. Young shoots of the current season's growth may become infected. Swellings develop on these affected twigs and they turn light green or yellow. The flowers and the young fruits also are often attacked, but these soon drop off and are unnoticed by the grower.

The life history of the leaf-curl fungus has not been so thoroughly worked out as have those of many other of the fruit-disease fungi. The following statements regarding the life history of the fungus seem to be fairly well established: The fungus overwinters chiefly in the form of spores lodged on the hairy bud scales and on the twigs. When the buds swell in the spring the tender leaf tissue is exposed, and if rains of sufficient length occur the spores germinate and grow into the young leaves. A little later the fungus forms its fruiting bodies just under the surface of the leaves. The fruiting bodies ripen their spores (ascospores), and these are distributed to the twigs and the dormant buds. This occurs before the diseased leaves dry up and drop to the ground. The spores remain on the hairy scales of the dormant buds through the remainder of the season and the winter, germinating, with favorable weather, in the following spring.

Control

The control of peach leaf-curl is much simpler than the control of other common fungous diseases of fruit. For example, in the control of apple scab there is no practical method of destroying the overwintering form of the fungus. The curl fungus, however, presumably overwinters in the form of spores on the bud scales and the twigs. One thorough application of 6½ gallons of lime-sulfur in 100 gallons of the spray mixture, or of 5–5–50 bordeaux mixture, applied at any time during the dormant period, will control peach leaf-curl. There is a growing tendency among commercial peach-growers to apply this spray in the fall. Delaying the spray until spring is dangerous, since the ground in the orchard is often too soft to permit spraying until after the buds have started to swell. When a rain period occurs after the buds have started in the spring, severe leaf-curl is likely to result if the spores have not been destroyed by a spray. Most failures to control leaf-curl are caused by failing to apply the spray before the buds swell. Poor control results also when the work is not done thoroughly. Every bud should be hit with the spray, and the terminals should be followed out to the tips, to insure perfect control. The spray should not be applied during freezing weather because of the danger of injury.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

Brown rot, an important and destructive disease, is better known as the *brown rot of stone fruits*, since cherries, plums, nectarines, and apricots are attacked by the same fungus. From the appearance of this disease at different times in the season, it is known as *blossom-blight*, *twig-blight*, *fruit-rot*, and *brown-rot canker*. While the losses to peach-growers from brown rot are more frequent and severe in the South, the disease is very

destructive in New York in warm, wet seasons. Certain varieties, such as Carman and Rochester, are especially susceptible in this State.

All peach-growers are familiar with the appearance of the disease on the ripening fruit, but many overlook the equally important stages on flowers, twigs, and branches.

The brown-rot fungus overwinters in cankers on the branches of trees and in the mummied fruit. About the time the peach buds begin to show pink, the fungus in the fallen mummies produces small, mushroom-like cups from which the ascospores are shot during rains. Other spores (conidia) also are liberated in great numbers from the mummies clinging to the trees and from the cankers on the limbs. These conidia are the more abundant and common form in the spring, and are more important than the ascospores in spreading the disease.

When either type of spore lodges on an opening bud or a blossom, it germinates and grows into the tissue, causing the blossom to turn brown and wither and usually to become covered later with a new crop of the powdery spores. In many cases the fungus grows from the blossom through the fruit spur and into the branch bearing the spur. Here it develops a dead, sunken area, or canker, which exudes large masses of gum. Conidia develop in great numbers in these cankers. Twigs that are attacked blight back to the branch, where a canker develops. Rains and warm, humid weather at the time when the peaches are ripening will cause a large number of the conidia to develop and be liberated from the cankers, and, if unprotected, a large proportion of the fruit may be attacked and may rot. In the order of its appearance, brown rot causes a loss to the commercial peach-grower in three ways: (1) it reduces the set of fruit through blossom blight; (2) it weakens the branches and reduces the bearing life of the trees through cankers on the limbs following twig and blossom blight; and (3) it causes direct loss to the fruit crop.

The reduction of the set of fruit through blossom blight is not of commercial importance in most years, although in certain seasons favorable to blossom-blight infection this has resulted in serious loss.

The weakening of the branches and shortening of the life of the orchard causes a very serious loss, particularly in the commercial peach belt of western New York. This loss is recognized by some leading growers, who take measures to control blossom blight with very evident profit to themselves.

The damage to the fruit is generally recognized, and control measures are applied by most commercial peach-growers.

Control

Sulfur has been found to be highly effective in the control of the brown-rot fungus. Formerly, self-boiled lime-sulfur was largely used, and this mixture is a very effective and safe material. Owing to the time and the care required in preparing this spray, and the difficulty experienced in obtaining good stone lime, most growers have replaced self-boiled lime-sulfur with dry-mix sulfur-lime spray or with sulfur dust. Both of these have given excellent control of brown rot.

The first application should be made when the blossoms are separated and are showing pink, or earlier if a rain period threatens. The second application is made when the shucks are falling. A third application is

applied, before rains, two or three weeks after the shucks have fallen, and the last spray or dust two to four weeks before the fruit ripens, depending on weather conditions.

A few growers apply lime-sulfur, diluted 1–50, for the summer sprays, but this material is extremely dangerous on peaches after the blossoming period. Even at dilutions of 1–300, lime-sulfur may seriously burn peach foliage. Before blossom time, lime-sulfur may be used with safety.

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

(See also under *Plum and Prune*, page 68)

The plum curculio is often a serious pest of the peach in orchards near stone walls, woods, or other hibernating shelters. The beetles make both feeding and egg-laying punctures in the fruit, and cause it to become scarred or wormy. The wormy peaches usually fall, and thus a large proportion of the crop may be lost unless control measures are employed.

Control

The plum curculio can be controlled by spraying with 2 pounds of lead arsenate in combination with the following formula, when the shucks are falling. Whenever lead arsenate is used on peaches, the additional lime is necessary to prevent arsenical injury.

Superfine sulfur	12 pounds
Hydrated lime	16 pounds
Casein spreader	1 pound
Water to make	100 gallons

The same result can be obtained by adding 13 pounds of hydrated lime to the standard dry-mix.

PEACH SCAB

(Caused by the fungus *Cladosporium carpophilum* Thümen)

Peach scab, known also as *freckles* and *black spot*, occurs to an injurious extent wherever peaches are grown in New York. The damage done by scab is not realized by many growers, who regard the disease as a necessary evil or mistake it for a peculiarity of the affected variety. There is no decay of the fruit, but its market value is lowered. The size is reduced and the fruit may crack. Diseased fruits often drop prematurely, and those that are picked do not ship well. Attacks are most general on late varieties.

Small, round, olive-black spots appear on infected fruits about six weeks after the petals have fallen. These lesions are usually on the upper side of the fruit. When they are abundant, cracking of the fruit may follow.

Affected twigs show nearly circular yellowish brown blotches with a dark gray or a bluish border. When these are abundant, the cambium is killed and the twigs die.

Leaves also are attacked. Brown, scattering spots develop midway between the main veins, in which the tissue dries up and finally falls away, leaving circular holes.

The fungus overwinters in the twigs, and infections usually occur four or five weeks after the petals have fallen.

Control

Where the regular spray schedule is followed, peach scab is controlled without difficulty.

ORIENTAL FRUIT-MOTH

(*Laspeyresia molesta* Busck)

The oriental fruit-moth is a serious pest of the peach now widely distributed through the peach-growing regions of the State. The species winters over as full-grown larvae in cocoons in protected places. In the spring these change to moths, which lay eggs on the foliage. The moths emerge over a long period, and there are at least four broods a year in New York. The larvae of the first brood attack the tips of growing shoots, entering near the tips and burrowing down the twigs for a short distance. This causes the terminal leaves to wilt, turn brown, and die. The larvae of the later broods not only attack the shoots but also infest the fruits. The first and second broods are fairly distinct, but the later generations overlap, so that the moths of three different broods are present on the trees at the same time toward the end of the season. The larvae generally do not attack the fruit until it is two-thirds mature. In many cases, little if any gum is exuded from the entrance holes in the peach, and so it is very difficult to determine without opening a fruit whether or not it is infested. As a result, much infested fruit reaches the market in spite of careful sorting.

Control

No satisfactory control measures have yet been devised. The usual spray methods effective against other pests have not given satisfactory results. The most promising method of reducing injury seems at present to lie in the direction of the importation, breeding, and liberation of parasites. The workers at the New York State Agricultural Experiment Station at Geneva are following this line of attack with promising results.

PLUM AND PRUNE

The main troubles for which commercial growers of plums and prunes find spraying necessary are plum curculio, leaf-spot, and brown rot. In some plantings, European red mite and black knot may require special attention. Occasionally, outbreaks of the fruit-lecanium scale necessitate an application of an oil spray.

SPRAY OUTLINE FOR PLUMS AND PRUNES

Dormant (After the sap has started and before the buds break)

Lubricating-oil emulsion, diluted to contain 3 per cent of oil (see page 81). This application is needed only in orchards infested by San José scale or fruit lecanium, or in plantings where European red mite is serious and where dust or dry-mix is to be used for subsequent applications.

Shuck spray (When the shucks are off young fruits)

Lime-sulfur	2 gallons
Lead arsenate	2½ pounds
Water to make	100 gallons
or	
Dry-mix sulfur-lime	16 pounds
Lead arsenate	2½ pounds
Water to make	100 gallons

This spray is applied for the control of curculio, leaf-spot, and brown rot. If dust is used, an 80–20 sulfur–lead-arsenate mixture is indicated.

Summer sprays (The first, two or three weeks after the shuck application; the second, two or three weeks before the fruit ripens. Both applications to be made before rain periods)

Lime-sulfur	2 gallons
Water to make	100 gallons
or	
Dry-mix sulfur-lime	16 pounds
Water to make	100 gallons

If a dust schedule is followed, applications of dusting sulfur are indicated.

Japanese varieties

On Japanese varieties, the same schedules as to time of application should be followed. In the dormant period the same materials are used, but in all later applications 16 pounds of dry-mix sulfur-lime spray or sulfur dust is substituted for the lime-sulfur.

EUROPEAN FRUIT LECANIUM

(*Lecanium corni* Bouché)

At intervals of several years, the European fruit lecanium, a large, brown, soft-bodied, scale insect, appears in injurious numbers more or less locally in New York plum orchards. It occasionally attacks quinces also.

The mature female scales are about ⅛ inch in length and resemble a small halved pea, colored brown. The eggs are produced in late May and in June, and are to be found filling the cavity under the scale previously occupied by the female. They hatch in about a month, and the young insects crawl out on the leaves where they settle down and remain stationary until September. They then migrate back to the twigs, where they pass the winter in a partly grown condition.

Badly infested trees are weakened and lose their foliage, and the fruit remains undersized or falls prematurely. The young scales produce a clear, sweetish liquid known as *honeydew*, which collects on the leaves and the fruit and serves as a medium for the growth of a fungus that smuts the fruit.

Control

The lecanium scale is easily controlled on plum and quince by spraying the trees while dormant with a lubricating-oil emulsion diluted to contain 3 per cent of oil, or with one of the miscible oils used according to manufacturers' recommendations.

EUROPEAN RED MITE

(*Paratetranychus pilosus* Canestrini & Fanzago)

(See also under *Apple*, page 29)

European red mites sometimes cause considerable injury to plums and prunes. When numerous they cause a bronzing of the leaves, which results in a dwarfing of the fruit and a reduction in shoot growth and fruit-bud formation.

Control

Summer sprays of dilute lime-sulfur, applied as for the control of plum curculio and leaf spot, will usually control red mite satisfactorily.

The shuck-fall spray is especially effective, since it comes at a time when the winter eggs have completed hatching and before summer eggs have been laid.

If dry-mix sulfur-lime spray or dust is used for the summer applications, an oil spray should be applied just before the buds open wherever red mite has caused serious damage and overwintered eggs are numerous. (For materials and dilutions, see page 66.)

PLUM CURCULIO

(*Conotrachelus nenuphar* Herbst)

The plum curculio is the most serious pest attacking plums in New York, and it causes considerable injury to cherries, peaches, and apples also. This insect is most abundant and destructive in orchards adjoining stone walls, hedgerows, and other protected situations, which offer shelter for the overwintering beetles.

The adult plum curculio is a rough-looking grayish beetle with a hump on the middle of each wing cover. The chewing mouth-parts are on the end of a long snout which projects from the head somewhat like an elephant's trunk. The beetles pass the winter in sheltered situations near the orchard, and appear on the trees in May, usually at about the blossoming period of domestic plums. Previous to the setting of the fruit, the beetles feed on the leaves and the petals. Soon after the petals have fallen, the beetles attack the fruit, which they injure both by feeding and by egg-laying. The eggs are deposited in the fruit in characteristic crescent-shaped cuts, which, on apples, enlarge as the fruit grows and form D-shaped russeted scars. The feeding punctures are small, circular excavations which are undercut around the edges. Feeding punctures may occur at any time during the season when the beetles are active. Egg-laying is limited mainly to a period of three weeks, beginning on stone fruits about the time the shucks are falling and on apples soon after petal-fall. The eggs hatch in about a week, and the larvae live in the flesh of the fruit and become full-grown about two weeks after hatching. The larvae are dirty yellow in color, thickset, and rather strongly curved, with a distinct head. Except in the case of the cherry, most of the fruits containing larvae fall to the ground. When mature, the larvae leave the fallen fruit and enter the soil to a depth of one or two inches, where they construct earthen cells. Most of the larvae leave the fruit during the first two weeks in July. After about two weeks in the soil, the larvae change through the pupal stage to beetles. The beetles of the new brood emerge from the ground

during August. They may feed on the fruit to a considerable extent during late summer and fall, but they do not lay eggs until the following spring. In New York there is only one generation of the plum curculio in a season.

Control

The plum curculio is controlled by sprays containing 2½ pounds of lead arsenate in 100 gallons of the spray mixture. The first spray is applied as soon as the shucks have fallen from the growing fruits. In badly infested orchards a second spray may be required a week later.

PLUM LEAF-SPOT

(Caused by the fungus *Coccomyces prunophorae* Higgins)

Plum leaf-spot is caused by a fungus which is very similar to the cherry-leaf-spot fungus in its life history (page 59) but matures slightly later in the spring. The leaf-spots on plum are similar in appearance to those on cherry, but the shot-hole effect is much commoner. The effect of heavy leaf infection is much more serious on the current season's plum crop than on the cherry crop, because a heavy fruit-drop often follows the leaf infection. The spray schedule followed for the control of plum leaf-spot consists of a spray when the shucks are off the young fruit, a second spray two or three weeks later, and a third spray before the fruit ripens. The last two sprays should be timed to precede rain periods. There is some evidence that during the season of 1928 an additional spray, applied soon after the petals had fallen, was of value in controlling plum leaf-spot. Lime-sulfur (2 gallons in 100 gallons of the spray mixture), dry-mix sulfur-lime spray, and sulfur dust, have all given adequate control when properly applied.

BROWN ROT

(Caused by the fungus *Sclerotinia americana* (Wormald) Norton & Ezekiel)

(See also under *Peach*, page 63)

The brown rot of stone fruits is a serious disease on plums and prunes in New York. The life history of the fungus causing this disease is given on page 64.

Control

Where the regular spray schedule is followed, adequate control of brown rot is obtained.

BLACK KNOT

(Caused by the fungus *Plowrightia morbosa* (Schweinitz) Saccardo)

Black knot is a serious disease of plum and prune. It occurs on wild and cultivated forms of both plum and cherry, but is much commoner on plum.

The disease affects only the woody parts. It is confined usually to the twigs, but is found occasionally on the larger limbs and the trunk. The knots vary from ½ inch to 1 foot or more in length, and from a fraction of an inch to 2 inches in circumference. The knots usually do not completely surround the limb. In the spring the young knots are olive green in color, and are firm but rather pulpy. Later the knots turn black and become hard and brittle.

The olive-green knots are the points from which the spores of the fungus are spread. During April, May, and June, some of these spores lodge on other trees, germinate, and grow into the bark and the growing tissue. The irritation causes the tree to develop a large amount of bark tissue, which appears in the fall as a slight swelling. In the spring the new knot enlarges and splits open, and the fungus soon forms its spores, giving the knot a velvety-green appearance.

Control

This trouble may be remedied by pruning out the knots during the winter or before growth starts in the spring. The cut should be made about 4 inches below the base of the visible swelling. A second inspection should be given the orchard during the latter part of May, to remove knots which were not visible in the winter but which would swell rapidly in the spring and produce spores that would spread the disease. It is important that all pruned knots be burned immediately. When knots develop on large limbs or trunks, the knotted tissue should be carefully removed for about ½ inch beyond the boundary of the knots. It is not necessary to remove much wood, even beneath the visibly knotted area. All plums, prunes, and cherries in the near vicinity, both cultivated and wild, should be pruned or removed.

Where black knot is a serious problem, a delayed-dormant spray should be applied about the time the buds are breaking, in addition to the regular shuck and summer sprays on plums and prunes. For the delayed-dormant spray, liquid lime-sulfur diluted 1–8 with water, or a 3–6–50 bordeaux oil-emulsion spray containing 3 per cent of oil, has given good results in Canada during the past four years.

QUINCE

Fortunately, the quince is subject to attack by only a comparatively small number of insects and diseases. In the past the most serious insect enemy has been the quince curculio, but the oriental fruit-moth, a pest relatively new to the State, threatens to become much more destructive. Among diseases subject to control by spraying, the most important is leaf-blight, although occasionally the Brooks fruit-spot may cause serious losses.

SPRAY OUTLINE FOR QUINCES

Dormant (In the spring before the buds start)

Lubricating-oil emulsion, diluted to contain 3 per cent of oil.

This spray need be applied only when the lecanium scale becomes abundant.

Pink spray (When the blossoms show pink)

Lime-sulfur	2½ gallons
Water to make	100 gallons

or

3–8–50 bordeaux mixture

or

Sulfur dust

This spray is applied for the control of leaf-blight.

For control of the oriental fruit-moth the schedule on page 73 should be followed. This schedule should control also the curculio and the codling moth. For control of leaf-blight and leaf-spot, two or three sprays after bloom may be required. Lime-sulfur 1–40 and 3–8–50 bordeaux mixture are both effective, but sulfur sprays are not compatible with the oil schedule suggested for control of the oriental fruit-moth. If the lead-arsenate schedule is followed for the oriental fruit-moth, either lime-sulfur or bordeaux mixture may be used.

QUINCE LEAF-BLIGHT AND FRUIT-SPOT

(Caused by the fungus *Fabraea maculata* (Leville) Atkinson)

Quince leaf-blight is prevalent on quinces in New York, and occurs also on pears. On quinces the disease is called *leaf-blight*, *black spot*, *fruit-spot*, and *scald*. Defoliation is common in nurseries and may occur on mature trees. As a result, the quince fruits remain small and subsequent crops are reduced. In light infestations, scattered spots are found on the fruit; in severe attacks, the fruits are badly spotted and become cracked and deformed.

The disease first appears on the upper surface of the quince leaf as circular, discolored spots with a reddish center and a dull border. Later the spots extend through the leaf, showing on the under surface, and the black fruiting bodies of the fungus appear in the center of the spots as conspicuous black dots. The spots are usually about ⅛ inch across but they may coalesce into extended brown areas. The appearance on the twig is similar to that on the leaf. The twig may be completely circled by the spot and may die as a result.

On the fruit the disease appears as circular blackish spots with a red or a white margin and a black dot at the center. The spots are somewhat sunken and may be as much as ¼ inch in diameter. When numerous they coalesce into deep brown or blackish areas, over which are scattered the black dots, or fruiting bodies, of the fungus (figure 18).

The fungus causing this trouble overwinters in the dead leaves in much the same way as does the apple-scab fungus. The fruiting bodies in these fallen leaves are usually ripe and ready to shoot out their ascospores by the blossoming time of the quince. The ascospores are discharged during wet weather and are carried by air currents up into the trees.

The spores that lodge on tender leaf tissue germinate and grow into the leaf, and about a week later the spots begin to appear. Later the summer spores are borne in the black fruiting bodies already mentioned, in the center of each spot. These spores are spread and start new infections during wet periods. The spots appear on the quince fruits when these have reached nearly mature size.

Further studies on this fungus are needed, but it appears probable that the spores from the quince will attack also pear, apple, hawthorn, and other closely related plants.

Control

Experimental data on the control of quince leaf-blight and fruit-spot are extremely meager. In one severely infected quince block in western New York, an experiment was conducted in 1924 by the late H. W. Fitch, who

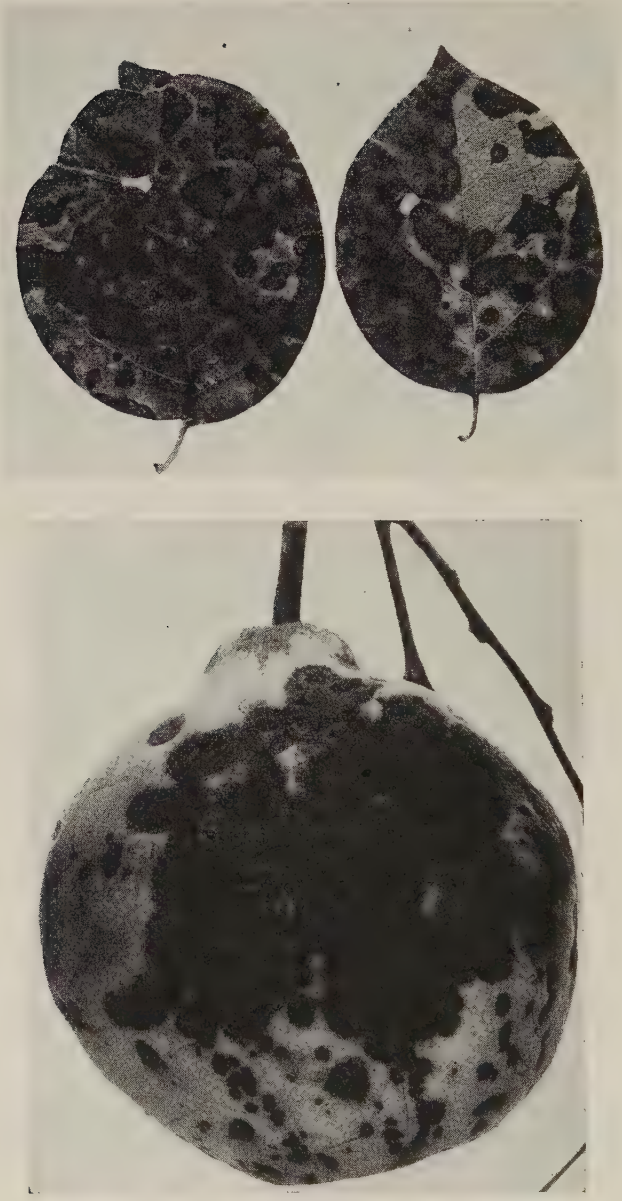

FIGURE 18. QUINCE LEAF-BLIGHT AND FRUIT-SPOT

used lime-sulfur 1–40, 3–8–50 bordeaux mixture, 90–10 sulfur–lead-arsenate dust, and 10–5–85 copper-lead-lime dust. The untreated trees showed 100 per cent leaf infection and 99 per cent fruit infection. All materials were applied at the pink and calyx periods, and three summer applications were made—the first, two and one-half weeks, the second, five weeks, and the third, nine weeks, after the calyx application. The lime-sulfur spray and the bordeaux-mixture spray gave excellent control of fruit and leaf infection, with 2 to 3 per cent fruit infection and 3 to 4 per cent leaf infection. The 90–10 sulfur–lead-arsenate dust gave commercial control, with 11 per cent fruit infection and 10 per cent leaf infection; the copper-lead-lime dust was rather ineffective, with 59 per cent fruit infection and 100 per cent leaf infection. This indicates that excellent control may be obtained with either lime-sulfur or bordeaux-mixture spray, and that commercial control may be obtained with 90–10 sulfur–lead-arsenate dust.

QUINCE CURCULIO

(*Conotrachelus crataegi* Walsh)

Most knotty quinces are the result of attack by a brownish gray, broad-shouldered, snout beetle, about ¼ inch in length, known as the *quince curculio*. In western New York these beetles usually appear on the trees in July, the date varying from year to year owing to weather conditions and the state of the soil in which the grubs have passed the winter. In feeding, the curculio cuts a small hole in the skin of the fruit by means of the jaws at the tip of its snout, and then eats out a cavity in the pulp. The eggs are deposited in similar cavities. The larvae, or grubs, burrow through the flesh. They become full-grown in about a month, and, leaving the fruit, fall to the ground. There, at a depth of 2 or 3 inches, they form an earthen cell in which the winter is passed in the larval stage. Pupation does not take place until the following spring.

Control

The quince curculio can be controlled by making two applications of lead arsenate, 2½ pounds in 100 gallons of the spray mixture. The first spray is applied when the beetles appear on the trees, and the second about a week later.

ORIENTAL FRUIT-MOTH

(*Laspeyresia molesta* Busck)

(See also under *Peach*, page 66)

The oriental fruit-moth is a very serious pest of quinces. Since quinces can be thoroughly sprayed without injury, the control of the insect on this fruit is much easier than on peaches.

Experiments conducted during the season of 1933 indicate that satisfactory control may be obtained by the use of a summer-oil–lead-arsenate combination. The use of 2 gallons of summer oil and 2½ pounds of lead arsenate to each 100 gallons of spray mixture, applied at two-weeks intervals beginning with the calyx application, gave 96 per cent clean fruit. Summer oil alone and lead arsenate alone also gave very satisfactory results.

While definite recommendations cannot be made on the basis of one season's results, it is suggested that the following procedure be given trial by quince-growers desiring to control the oriental fruit-moth: For the calyx application and the sprays applied two and four weeks later, use 2 gallons of summer oil and 2½ pounds of lead arsenate in 100 gallons of spray mixture. For the next four applications, substitute 1 pint of nicotine for the lead arsenate. This should obviate the necessity of washing the fruit for removal of residue and should at the same time give satisfactory control. However, no difficulty was experienced in removing residue to the required tolerance when the oil-lead combination was used for the entire season.

It seems obvious that the trees must be pruned and thinned so that thorough applications can be made, if satisfactory control is to be obtained.

BROOKS FRUIT-SPOT

(Caused by the fungus *Mycosphaerella pomi* Passerini)

(See also under *Apple*, page 41)

The Brooks fruit-spot is more commonly found on apple, but it occurs in serious amounts on quince also. In one orchard in the southern Hudson Valley in 1928, more than 80 per cent of the fruit was so spotted by this fungus as to be unmarketable. The owner of this orchard suffered an equally heavy loss in 1927. No spray schedule was followed in either year.

The disease usually appears on quince fruit in late August. The spots are ¼ inch or less in diameter, with the surface slightly sunken. The blotched area at first is of a darker green color than the surrounding area, and later it becomes black. The spots or blotches are usually more numerous near the blossom end of the fruit, and frequently unite, forming large blotched areas.

Control

Limited experimental data obtained in a heavily infected quince orchard indicate excellent commercial control with one additional cover spray of 3–8–50 bordeaux mixture, in addition to the calyx and curculio sprays of the regular schedule. This spray was applied about two weeks after the curculio spray.

EUROPEAN FRUIT LECANIUM

(*Lecanium corni* Bouché)

(See also under *Plum and Prune*, page 67)

The quince is sometimes seriously infested with the same lecanium scale as that which attacks plum. When it is abundant, a special spray for its control may be necessary, using the same material as is used for the insect on plum (page 67).

SPRAY MATERIALS

The number of spray materials that can be used advantageously in the average commercial orchard under New York conditions is limited to a relatively short list of standard fungicides and insecticides. The most

important of these are sulfur, lime-sulfur, lead arsenate, and nicotine sulfate, for general use, and bordeaux mixture, dry-mix sulfur-lime, and oil preparations, for special purposes. Of the many proprietary spray compounds on the market, few, if any, are superior to the standard materials. They are usually much more expensive, are less effective, and in some orchards are much more toxic to the trees. The large sums of money expended each year on materials of this kind, together with the losses due to ineffective control from their use, constitute a serious drain on the resources of the fruit interests of the State.

It is the custom to divide spray materials into insecticides and fungicides, but in the light of present-day knowledge this distinction is not so clear-cut as was formerly thought to be the case. Lime-sulfur is both an effective insecticide and an efficient fungicide. Lead arsenate is used primarily for control of chewing insects, but when combined with lime-sulfur it has considerable value as a fungicide also. Bordeaux mixture is essentially a fungicide, but it may serve as an effective insecticide as in the case of the potato leaf-hopper. Nicotine alone, among the standard spray materials, is used exclusively for its insecticidal properties.

The selection of the standard materials now generally used is not a matter of chance, but is based on results obtained by practical growers during many years of experience. That this choice is sound, in the main, has been proved time and again by the experimental tests conducted by the workers at experiment stations.

It is a very expensive matter to conduct tests of the relative value of different kinds of spray materials if dependable results are to be obtained. The average fruit-grower has neither the time nor the funds for experimental work of this kind. Unless the experiments are properly planned and carefully conducted, the results are likely to be misleading. In general, it is better for the individual grower to rely on the results obtained by experiment stations, which are supplied with public funds for this purpose.

SULFUR SPRAYS

Lime-sulfur solution

Lime-sulfur has a wide range of usefulness in orchard spraying. At the higher concentrations it is effective against peach leaf-curl, San José and oyster-shell scale, and the eggs of the pear psylla. At the summer strength of 1–40 it is the chief reliance in New York in the control of such important diseases as apple scab and cherry leaf-spot, and, when used throughout the summer, prevents injury from the European red mite.

Lime-sulfur solution is prepared by boiling freshly burned high-grade calcium lime with sulfur and water. The commercial concentrate generally sold is a clear, orange-red solution usually containing between 25 and 26 per cent of total dissolved sulfur and testing from 32° to 33° Baumé. While most commercial brands test approximately as indicated, there may be considerable variation, and the safest plan is to test each barrel with a hydrometer, preferably one marked with a Baumé scale. All recommendations in this bulletin as to the quantity of lime-sulfur to be used are based on a solution testing 32° Baumé. If solutions of other strengths are used, corrections should be made according to table 1.

TABLE 1. LIME-SULFUR DILUTION TABLE

Hydrometer reading in degrees Baumé	Gallons of lime-sulfur used in 100 gallons of spray			
32° (standard test)	11	6½	2½	2
20°	22½	13	5	4
21°	20¾	12¼	4¾	3¾
22°	19¼	11¼	4¼	3¼
23°	18¼	10½	4	3¼
24°	17	10	3¾	3
25°	16	9¼	3½	3
26°	15	8¾	3½	2¾
27°	14¼	8¼	3¼	2½
28°	13½	8	3	2½
29°	12¾	7½	2¾	2¼
30°	12¼	7¼	2¾	2¼
31°	11½	6¾	2½	2
32°	11	6½	2½	2
33°	10½	6¼	2¼	2
34°	10¼	6	2¼	1¾
35°	9¾	5¾	2¼	1¾

In recent years it has been the practice to ship commercial lime-sulfur in steel drums. In many cases these drums have previously been used for oil. Unless the drums are carefully cleaned, there is danger of injuring the trees from the mixture of oil and lime-sulfur.

It is possible to make concentrated lime-sulfur solution on the farm if one wishes to go to the trouble and the expense for equipment. Directions for preparing the homemade solution can be obtained from the state experiment stations.

Other sulfur sprays

Much confusion exists regarding the sulfur sprays in common use, owing to the similarity of names and the variety of names often applied to the same material. *Lime-sulfur solution* refers to the liquid obtained by boiling lime, sulfur, and water. *Dry lime-sulfur* is a yellow, pungent powder obtained by evaporating lime-sulfur solution. *Dry-mix sulfur-lime*, also known as *Jersey dry-mix* and as *wettable sulfur*, is a dry mechanical mixture of sulfur, lime, and casein spreader, to be used in water as a spray. The name *wettable sulfur* is applied also to a number of sulfur materials containing a substance for wetting the particles when mixed with water. The relative merits of these materials for scab control have not yet been definitely determined. The wettable sulfurs are effective when perfectly timed, but they do not possess the after-rain effect of liquid lime-sulfur. Dry lime-sulfur is intermediate between liquid lime-sulfur and the elemental-sulfur applications, in after-rain control. The elemental-sulfur applications are also much less effective in burning out scab lesions that are already present on the foliage.

One of the wettable sulfurs which has attracted considerable attention during recent years is *flotation sulfur*. This by-product of illuminating-gas manufacture is now on the market in both paste and powder form. The experimental evidence in this State indicates that this material is less toxic to apple foliage than is lime-sulfur, and is apparently superior to dry-mix sulfur-lime as a fungicide

Calcium sulfide is a finely powdered monosulfide of calcium which was

developed in Virginia as a less toxic fungicide for summer sprays on apples and peaches. It has been found to be an effective fungicide under Virginia conditions, but limited experimental evidence in this State indicates it to be a considerably less effective fungicide than lime-sulfur for the control of apple scab.

Sodium sulfide is a compound of sulfur and sodium. It is sold under a number of trade names, both in the form of a powder and as a solution. It has been discarded by most commercial fruit-growers because of the frequency with which injury to the trees results from its use.

Potassium sulfide is a compound of sulfur with potassium, which was formerly used to some extent but which has now practically disappeared from the market.

Dry lime-sulfur

Dry lime-sulfur is liquid lime-sulfur with the water (comprising about 70 per cent of its weight) removed. The removal of the water changes somewhat the state of the sulfur. The percentage of sulfur in the polysulfide, or soluble, form is reduced during the evaporating process. Tests made at various experiment stations indicate that about 4 pounds of the powder is required to equal 1 gallon of lime-sulfur concentrate when used for spraying at summer strength. It may readily be seen that at current prices per pound the evaporated product is much more expensive than the liquid. Dry lime-sulfur is being recommended and used by some Middle-Western States as a means of reducing the danger of spray injury. In New York, when a milder spray substitute for the liquid lime-sulfur is required during weather conducive to injury, the tendency has been to use one of the wettable sulfurs for this purpose, rather than dry lime-sulfur.

Dry-mix sulfur-lime

Dry-mix sulfur-lime is now usually prepared according to the following formula:

Superfine sulfur	12 pounds
Hydrated lime	3 pounds
Casein spreader	1 pound

For each 100 gallons of the spray material, 16 pounds of this mixture is required.

The materials are mixed dry in the proportions given in the formula, a screen or a dust mixer being used, and are stored in a dry place until the time for their use. With the tank half full of water and the agitator running, the required quantity of the dry material is washed through the strainer into the tank by means of the open spray gun.

Some growers weigh out the correct amount of casein spreader, hydrated lime, and sulfur for each tank. The casein spreader is first washed through the screen into the tank, and the hydrated lime and the sulfur are then washed through with the open spray gun. If the tank is more than half full of water and the agitator is running, this method is found to be as satisfactory as the previous dry-mixing of the materials.

Dry-mix sulfur-lime has supplanted self-boiled lime-sulfur for use on peaches, because it is much more convenient, is equally effective, and, con-

sidering the labor cost, is cheaper than the self-boiled material. It has been discovered, however, that when lead arsenate is applied with dry-mix, it is more likely to cause arsenical injury to such tender trees as the peach than when it is combined with self-boiled lime-sulfur. To decrease this danger, not more than 2 pounds of lead arsenate should be used and excess hydrated lime should be added to make 16 pounds of lime for each 100 gallons of the spray mixture on peaches.

Dry-mix sulfur-lime is one of the wettable sulfurs used as a substitute for lime-sulfur for summer sprays on apples and for the bordeaux-mixture spray on pears. Dry-mix is less effective than summer-strength lime-sulfur in checking the spread of apple scab already present in the orchard. The cost of the dry-mix materials is somewhat higher than that of lime-sulfur at summer strength.

Experienced growers who are using dry-mix for summer sprays on apples do so only when they are convinced that they already have the scab under commercial control in their orchards. They wish to reduce the danger of spray injury to foliage and fruit, and to insure as high a finish as possible on the fruit.

It should be remembered, however, that under certain unfavorable weather conditions injury may result with any of these materials. This is most likely to occur when heavy applications are made during or immediately preceding periods of excessive heat. Under such conditions, applications even of sulfur dust may cause serious burning.

SULFUR DUST

Sulfur dust is generally used in combination with lead arsenate, but for certain purposes it is used alone. To be most effective, it should be so finely ground that 90 per cent will pass through a screen having 300 meshes to the inch. When sulfur dust is not combined with lead arsenate, a small percentage of "fluffer" is added to prevent packing of the dust and to insure a fine cloud of dust when it is applied.

New sulfur dusts have come into use which contain colloidal sulfur, and others which contain dry lime-sulfur. These materials, and also sulfur dust containing various oxidizing and activating agents, are now being extensively tested.

LEAD ARSENATE

For many years, lead arsenate has been the standard arsenical used in the commercial orchards of New York. This is because it is much safer, stays suspended in water longer owing to its extreme fineness, and adheres more firmly to the plant, thus protecting the crop over a longer period of time, than any of the earlier types of arsenicals such as paris green and london purple. Lead arsenate can be used with lime-sulfur sprays as well as with most other standard fungicides and insecticides. Unfortunately, lead arsenate, when used in the later applications, is likely to leave objectionable lead residues, as well as arsenical residues, on the fruit. If used in these sprays, it should be applied with great care or the grower should be prepared to remove excess residue by washing.

When employed in dusting orchard fruits, from 5 to 20 per cent by weight of lead arsenate, depending on the insects to be combated, is used in combination with sulfur dust. A 90–10 sulfur–lead-arsenate dust is most commonly used.

CALCIUM ARSENATE

Calcium arsenate is similar to lead arsenate, the lead being replaced by calcium. It is the most promising substitute for lead arsenate for use in the later applications. It is effective against the cherry fruit-fly and the apple maggot, but is not quite so effective in codling-moth control as is lead arsenate. Under certain conditions it has a greater tendency to cause foliage injury. It is not safe to be used alone on orchard trees, because of the danger of burning. It should not be used on peaches, because of the danger of injury to leaves, twigs, and fruit. Calcium arsenate contains a larger percentage of arsenic than does lead arsenate, and therefore not so large a quantity is required. It is less adhesive, but, in view of its higher arsenical content, it should probably be used at present at about ¼ less strength than should lead arsenate. It is less stable than lead arsenate.

NICOTINE

For spraying purposes, nicotine is sold usually in the form of nicotine sulfate. The standard brands of nicotine sulfate on the market contain 40 per cent of nicotine. Nicotine sulfate is not volatile, but the fumes of the nicotine are liberated when the material is applied as a spray in combination with lime-sulfur, dry-mix sulfur-lime, or bordeaux mixture. If used in water alone, nicotine sulfate is not effective unless 3 to 5 pounds of soap is dissolved in each 100 gallons of the spray mixture. Recently a preparation has been placed on the market which contains 50 per cent of nicotine in the free, or uncombined, state. This has been recommended for use with certain oil sprays. Under the conditions prevailing in this State, such a combination has a very narrow field of usefulness.

Nicotine dust is usually made by mixing nicotine sulfate with hydrated lime. Nicotine-lime dusts can be bought ready-mixed, or they can be prepared in a ball-mixer or a self-mixing duster. Since the commercial brands of nicotine sulfate contain 40 per cent by weight of nicotine, 5 pounds, or 2 quarts, of this material is added to 95 pounds of hydrated lime to give a dust containing 2 per cent of nicotine. For a 3-per-cent-nicotine lime dust, 7½ pounds, or 3 quarts, is required. Since the nicotine strength is likely to deteriorate if the material is stored for a considerable time, it is well to use only freshly mixed dust.

SOAP

Soaps are used with nicotine sulfate and water to liberate the nicotine and to increase the wetting and spreading qualities. They are used also in preparing certain boiled-stock oil emulsions.

The soap most commonly used for spraying purposes is potash fish-oil soap. This is a soft soap, dissolving easily in water. Soda fish-oil soap

is a harder soap which is sometimes used but is more difficult to dissolve. Resin fish-oil soap has the advantage of not curdling in hard water or when used in spray tanks containing lime residues. Laundry soaps are used occasionally, but these are difficult to dissolve and vary greatly in the amount of free alkali present. Some brands of flaked soap dissolve rather readily and are convenient to use.

Soaps differ considerably in water content. The amount of soap to be used, therefore, varies from 3 to 5 pounds in 100 gallons of the spray mixture. For safety, a soap with only a little free alkali should be employed. In no case should soap be used in combination with lime-sulfur.

OIL SPRAYS

Oil sprays have been found of considerable value in the following cases: for use against the lecanium scale and the San José scale; in severe infestations of leaf-roller eggs, for which these sprays are almost indispensable; for the pear psylla, to check egg-laying and to destroy the newly hatched nymphs; and for killing the eggs of the European red mite when a seasonal program of lime-sulfur sprays on apple cannot be followed. Oil sprays have been widely advertised for aphis control on apples, but their desirability for this purpose is not clearly established under New York conditions. While oil sprays with suitable oil content, carefully applied, do reduce appreciably the number of aphids, they are not, on the whole, so satisfactory as lime-sulfur and nicotine sulfate. Growers contemplating the use of oil sprays should consider carefully the different brands from the viewpoints of safety and insecticidal efficiency. It is hoped that oil sprays more satisfactory in these respects will be placed on the market sometime in the future.

The use of oil sprays may be attended with more or less danger of injury to the tree. Injurious cumulative effects may result from yearly applications, although with certain grades of oil the possibility of danger from this practice has been overemphasized. Until more is known in regard to the composition of oil sprays that are safe and efficient, the possibility of injury from their continuous use should be kept in mind and the grower should be prepared to discontinue such applications for a time and to rely on other spray material.

Several factors influence the likelihood of injury and the degree of damage produced. Among these may be mentioned the type of oil used, the weather conditions at the time of application, the vigor and the variety of the tree, and the stage of bud development at the time of treatment. The injury may become evident immediately after the application, as indicated by the burning of the tips of the leaves and the killing of the buds, or it may appear later as injury to the bark, causing a dying-back of the twigs and the branches.

A large number of oil preparations are available for spray purposes. These may be divided roughly into miscible oils and oil emulsions; in the miscible oils the emulsifier is soluble in the oil, and in the emulsions the oil is dispersed in the emulsifier. Miscible oils are proprietary oil products which are usually high in oil content and are rendered miscible by the presence of an emulsifier so that they mix readily with water when placed in the spray tank. Owing to the fact that miscible oils vary in composi-

tion according to the formulas of the different manufacturers, it is advisable to follow the manufacturers' recommendations as to dilution and methods of application.

Oil emulsions

In recent years, certain grades of lubricating oils have been found to have decided merit for spraying purposes. The kinds most generally used in this State are Junior Red Engine and Diamond Paraffin. Oils having the following specifications should prove satisfactory:

Viscosity at 100° F. (Saybolt), 90–215 seconds; specific gravity, 0.88–0.90; Baumé gravity, 24°–28°; flash point, 350°–280° F.; fire point, 400°–435° F.; cold test, 18°–32° F.; volatility after four hours (220°–230° F.), not over 2 per cent.

Stable concentrated emulsions of these or similar grades of oil can be purchased on the market under various trade names. In most of these preparations the emulsifier is soap, gum, clay, casein, or combinations of these and other materials. The oil content of the preparations should be indicated on the label, and is usually about 66 per cent. If a 66⅔-per-cent stock emulsion is used, it should be diluted according to the following directions:

For a 2-per-cent emulsion, use 3 gallons of stock solution
For a 3-per-cent emulsion, use 4½ gallons of stock solution
For a 4-per-cent emulsion, use 6 gallons of stock solution
For a 6-per-cent emulsion, use 9 gallons of stock solution
} for 100 gallons

While these stock emulsions are reasonably stable, if they are allowed to freeze or are stored for considerable periods of time some of the oil may separate out. If the stock emulsion shows any considerable amount of free oil, and preliminary efforts show that it will not emulsify properly, it is unsafe for use and should be discarded.

Lubricating-oil emulsions can be prepared for immediate use directly in the spray tank. Emulsions prepared in this way are considerably less expensive and the spray material is equally effective. The cold-mixed emulsions are prepared by several formulas. The one preferred under commercial conditions is prepared as follows: Place 10 gallons of water in the spray tank, or enough to be thoroughly churned by the agitator. Do not start the engine. For each 100 gallons of spray, add 1 pound of copper sulfate dissolved in water, then add 2 pounds of hydrated lime also in water, stirring meanwhile with a stick or a paddle. Start the engine, and slowly pour in the proper number of gallons of oil to give the percentage desired in the completed mixture. Direct the spray gun into the tank and continue the agitation until the oil is properly emulsified. In a few minutes, or as soon as the oil is thoroughly emulsified, fill the tank with water, keeping the engine running continuously until the tank has been sprayed out. If it is necessary to stop the sprayer, and any considerable quantity of oil separates out, the remainder in the tank should be discarded unless it can be brought back into an emulsion. If more copper is desired for fungicidal purposes, use 3 or 4 pounds of copper sulfate and twice as many pounds of hydrated lime.

Emulsions of highly refined mineral oils, often referred to as *white oils*, designed for use on foliage, are also on the market but their place in the New York spray program is as yet not established. One serious drawback to their use is the danger of injury when they are applied within a short time previous to, or within a month after, the use of lime-sulfur or sulfur dust. There seems at present to be no definite need for these white-mineral-oil sprays under New York conditions.

TAR-DISTILLATE EMULSIONS

For four years the New York Agricultural Experiment Station at Geneva has been testing various brands of tar-distillate emulsions, known also as *tar washes*. These preparations consist chiefly of coal-tar creosote oil emulsified with various materials so that they mix readily with water. Some of the commercial brands contain also a certain percentage of petroleum oil, the proportion varying with different preparations. The effect of these materials on aphis eggs, bud moth, and oyster-shell scale depends on the proportion of creosote oil present. Tar-distillate emulsions are not effective against the San José scale. In some brands, petroleum oil has been added to make them effective against this scale also. It has been found, however, that, for severe infestations of San José scale, about 3 per cent of petroleum oil is necessary in the diluted mixture, whether or not it is combined with tar-distillate emulsions. It has been found also that there is danger of injuring the trees by spraying with mixtures containing more than 6 per cent of total oils, either petroleum, creosote, or a mixture of both.

If the trees have been injured by low winter temperatures, these materials should be used with great caution.

In selecting a brand of tar-distillate emulsion, the grower should satisfy himself as to the percentage of creosote oil and of petroleum oil present. The tar acid content should be not more than 10 per cent, and perhaps 5 per cent would be better. Occasionally a brand will not mix well with the water available on the farm. The grower should make sure that the brand which he selects will be satisfactory in this respect.

The recommendations for dilutions in this bulletin are given in the percentage of creosote oil in the diluted mixture. This is necessary because of the wide variation in the composition of the commercial preparations now on the market. These vary from 36 to 90 per cent in creosote-oil content, and from 0 to 46 per cent in petroleum oil. If the percentage of creosote and petroleum oils in the emulsion is known, the proper dilution can be determined from table 2.

Dilutions likely to be injurious to the trees are omitted.

If tar-distillate emulsion is to be used for the control of San José scale in addition to the insects listed in table 2, petroleum-oil emulsion should be added according to table 3. Not all brands of petroleum emulsion will mix with a particular tar-distillate emulsion. If the two emulsions are obtained from the same manufacturer, they are more likely to be compatible.

In table 3, the quantity of petroleum oil is indicated in percentage of actual oil. For the convenience of growers in computing the quantity of oil to be added, table 4 is presented, in which the number of gallons to be added is given for petroleum-oil emulsions containing 83 and 66 per cent of oil.

TABLE 2. DILUTION TABLE FOR TAR-DISTILLATE EMULSIONS

Per cent of oil in stock emulsion as purchased		Number of gallons of emulsion to be used for 100 gallons of spray mixture				
Creosote	Petroleum	For cherry aphis (1.8 per cent creosote oil)	For rosy aphis (2.4 per cent creosote oil)	For light infestation of bud moth or oyster-shell scale (3 per cent creosote oil)	For scurfy scale (3.6 per cent creosote oil)	For severe bud-moth infestation (4.5 per cent creosote oil)
90	0	2.0	2.7	3.3	4.0	5.0
83	0	2.2	2.9	3.6	4.3	5.4
80	0	2.3	3.0	3.8	4.5	5.6
70	13	2.6	3.4	4.3	5.1	6.4
65	15	2.8	3.7	4.6	5.5	6.9
60	23	3.0	4.0	5.0	6.0	7.5
50	33	3.6	4.8	6.0	7.2	..
40	40	4.5	6.0	7.5	..	..
37	46	4.9	6.5	..	..	..
36	44	5.0	6.7	..	..	..

TABLE 3. PERCENTAGE OF PETROLEUM OIL TO BE ADDED FOR SAN JOSÉ SCALE

Per cent of oil in stock emulsion as purchased		Per cent of petroleum oil to be added		
Creosote	Petroleum	For cherry aphis, San José scale	For rosy aphis, San José scale	For light infestations of bud moth, San José scale
90	0	3.0	3.0	3.0
83	0	3.0	3.0	3.0
80	0	3.0	3.0	3.0
70	13	2.7	2.6	2.4
60	23	2.3	2.1	1.8
55	15	2.5	2.3	2.2
50	33	1.8	1.4	1.0
40	40	1.2	0.6	0.0
36	44	0.8	0.0	..
37	46	0.8	0.0	..

TABLE 4. NUMBER OF GALLONS OF PETROLEUM-OIL EMULSION TO BE ADDED TO EACH 100 GALLONS OF THE SPRAY MIXTURE TO BRING THE DILUTED MIXTURE UP TO SCALE STRENGTH

Per cent of oil in stock emulsion as purchased		For rosy aphis, San José scale		For light infestations of bud moth, San José scale	
Creosote	Petroleum	Petroleum emulsion			
		83 per cent	66 per cent	83 per cent	66 per cent
90	0	3.6	4.5	3.6	4.5
83	0	3.6	4.5	3.6	4.5
80	0	3.6	4.5	3.6	4.5
70	13	3.0	3.9	2.9	3.6
60	23	2.5	3.2	2.2	2.7
55	15	2.6	3.5	2.7	3.3
50	33	1.7	2.1	1.2	1.5
40	40	0.7	0.9	0.0	0.0
36	44	0.0	0.0	..	..
37	46	0.0	0.0	..	..

If 6.5 gallons of the 37–46 emulsion for 100 gallons of spray mixture is used, it will give 3 per cent of petroleum oil for the San José scale; if the 36–44 emulsion is used, 6.8 gallons will be required. If either of the emulsions is used for the control of both light infestations of bud moth and the San José scale, 0.7 gallon of 83-per-cent tar-distillate emulsion should be added.